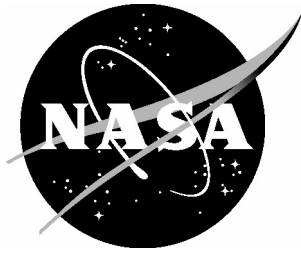


NASA/CR-2005-213762



## 757 Path Loss Measurements

*Kent Horton, Mitch Huffman, Brian Eppic, and Harrison White  
Delta Air Lines, Inc., Atlanta, Georgia*

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June 2005

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# 757 Path Loss Measurements

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## **1 INTRODUCTION**

NASA and Delta continue to collect quantitative data through the Cooperative Agreement NCC-1-381. Task 5B (757 Path Loss Measurement) was completed and this report collects and summarizes the data collected. Path Loss Measurements were obtained on three (3) GPS equipped 757 aircraft. Systems measured were Marker Beacon, LOC, VOR, VHF (3), Glide Slope, ATC (2), DME (2), TCAS, and GPS.

## **2 PURPOSE**

The purpose of this activity is to develop an engineering basis for assessing the EMI susceptibility of comm/nav system on commercial aircraft from RF sources operated inside aircraft or at close range outside the aircraft. Inside source locations included the cockpit window and seats, passenger cabin windows, seats, aisle, and doorways.

This data will provide the basis for assessing the EMI (Electromagnetic Interference) safety margins of comm/nav (communication and navigation) systems to portable electronic device emissions. These Portable Electronic Devices (PEDs) include all devices operated in or around the aircraft by crews, passengers, servicing personnel, as well as the general public in the airport terminals. EMI assessment capability is an important step in determining if one system-wide PED EMI policy is appropriate.

This data may also be used comparatively with theoretical analysis and computer modeling data sponsored by NASA Langley Research Center.

## **3 TECHNICAL APPROACH & PROCEDURES SETUP AND CALIBRATION**

The methodology used to collect data is based on the results from a succession of previous experiments that revealed the basic principles of the propagation of signal from a source inside an aircraft out to the comm/nav antennas. These antennas are mounted on various parts of the exterior surface of the aircraft.

The comm/nav systems were tested one at a time. Each receiver was removed one at a time from the rack and an adapter fitted to connect from the rack connector to a RG214 test cable. This cable is run from the avionics bay to the test equipment location through a cockpit window. The receiver rack cable was connected to the spectrum analyzer input. A second test cable was connected to the spectrum analyzer generator output. The other end of the cable was connected to the test source antenna. This could be a Biconical or Horn depending on frequency range of the source being simulated. (Reference: Attachment 1 Figure 2 for test setup).

All cables, amplifiers, signal source & spectrum analyzer and test antennas are calibrated prior to test, or verified as calibrated by use of the manufacturer's data. This

allows the collected data to be corrected after the fact, to remove any effect introduced by the test equipment. The source antenna type, polarization, power and location are recorded in a data collection log. The raw uncorrected power received by the spectrum analyzer is entered in the log using the on-screen marker of frequency and power level.

The spectrum analyzer's tracking generator was used as the source signal for all measurements. In most cases, a 37dB power amplifier was used to boost the transmitted signal. All long cable runs were RG214 double shielded coaxial cable. A short adapter cable was used between the spectrum analyzer output and the power amplifier.

The spectrum analyzer and its internal source were calibrated, using the internal routine, at each aircraft setup before collecting data. The source settings, source antenna type, and cables used to connect the equipment were recorded for each comm/nav system measured as well as the source location. Attachment 1 provides additional detail regarding the measurement procedure. This attachment was prepared by Madiha Jafri as a NASA Graduate Research Student.

## **4 DATA GATHERED / STATISTICAL ANALYSIS**

### **4.1 Introduction**

Based on previous statistical and analytical studies of data for the 767 and 777, it was found that the VHF and GPS systems showed a higher susceptibility to interference due to lower path losses from the cabin to the comm/nav system's receiving antenna. The VHF system is the primary communication link between the aircraft and the ground and is considered a critical system. The GPS system is the most accurate navigational equipment on board the aircraft. GPS can enhance flight safety for terrain avoidance awareness and accurate navigation through controlled airspace or during free flight. Therefore, it was decided to focus our attention on these two significant systems.

The report covers basic statistical techniques, the analysis of the path loss data at the doors and emergency exits, the analysis of path loss data at the windows, and any inferences that can be made regarding worst case path loss for the entire 757 fleet, development of equations that can estimate the path loss at any given passenger location, and suggestions for future studies.

### **4.2 Basic Statistical Analysis of 757 Data**

For any statistical study the first thing that must take place is the characterization of the data and the verification that data is normal data. If a sub-group of data is normalized, then we have the ability to make various inferences about the data and how it may apply across the entire fleet of 757s.

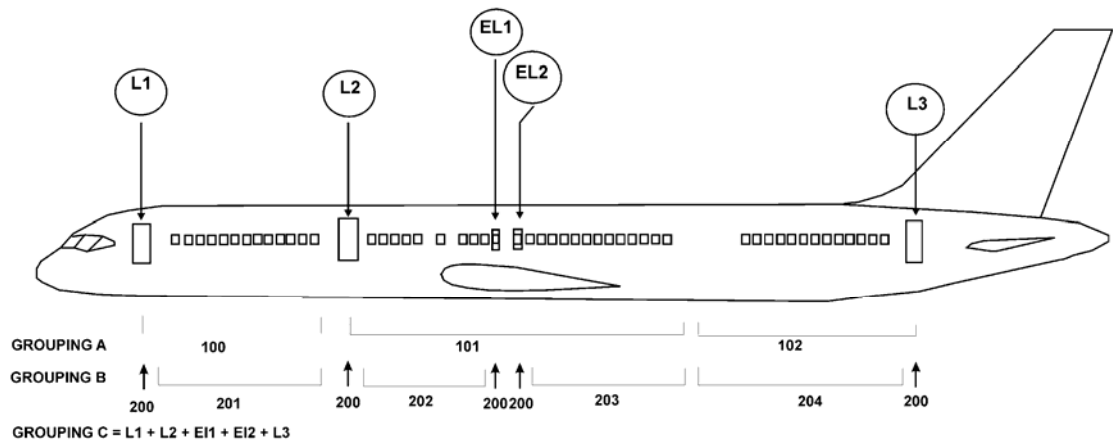
To perform the characterization we looked at data for particular systems and then took the grand average for each system across all aircraft. In all cases, the analysis was shown not to be normalized data. This result can occur due to variations ( $\sigma^2$ ) within the system being measured. Some of the variations that can take place are as follows:

- $\sigma^2_{\text{AIRCRAFT}}$  – The variation due to Boeing’s and sub-contractor manufacturing processes. Also, aircraft usage and repair history will add variation between aircraft.
- $\sigma^2_{\text{ENVIRONMENT}}$  – The variation due to weather and temperature, whether the tests were performed indoors or outdoors, exiting EMI from near by sources, and other items that were not controllable by the test group.
- $\sigma^2_{\text{A/C EQUIPMENT}}$  – The variation between LRUs, antennas, and their wiring.
- $\sigma^2_{\text{MEASUREMENT SYSTEM}}$  – This encompasses variation within the cables, measurement instrument, the measurer, the actual angle, tilt, and position of the antenna, and the repeatability of the antenna holder.

The total variation is the combination of all factors of variance.

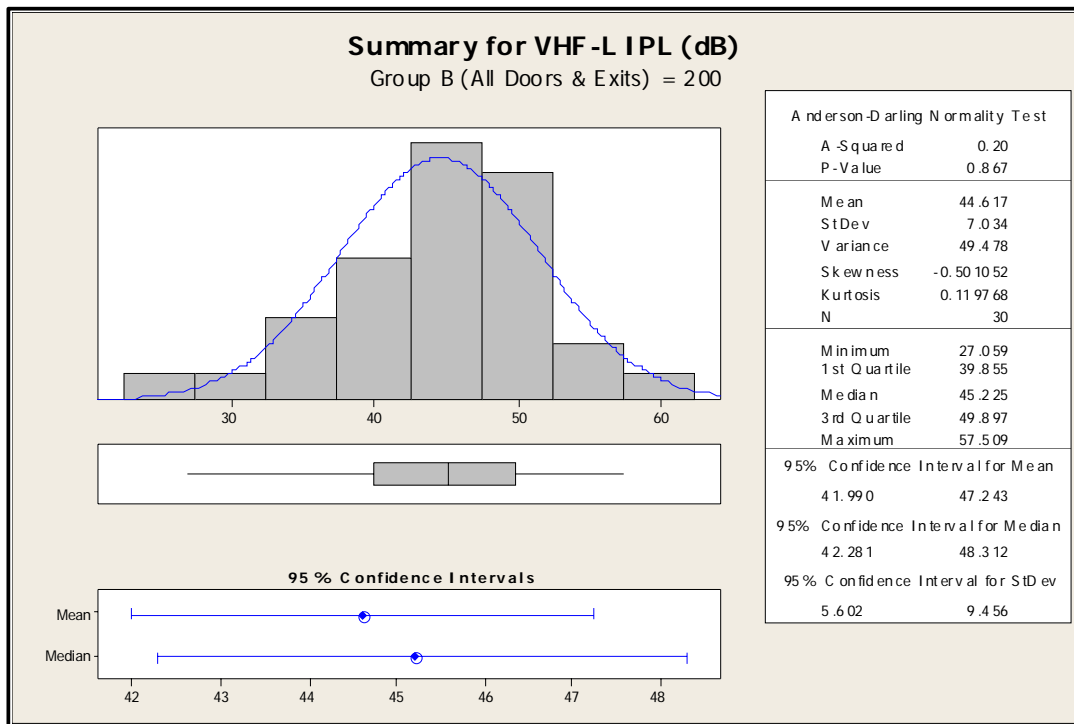
$$(1.1) \quad \sigma^2_{\text{Total}} = \sigma^2_{\text{AIRCRAFT}} + \sigma^2_{\text{ENVIRONMENT}} + \sigma^2_{\text{A/C EQUIPMENT}} + \sigma^2_{\text{MEASUREMENT SYSTEM}}$$

Much of the variation listed above is uncontrollable or has yet to be measured and accounted for. In order to mitigate some of the issues of unknown variances, the data was sub-grouped in several different ways as shown in Figure 1.

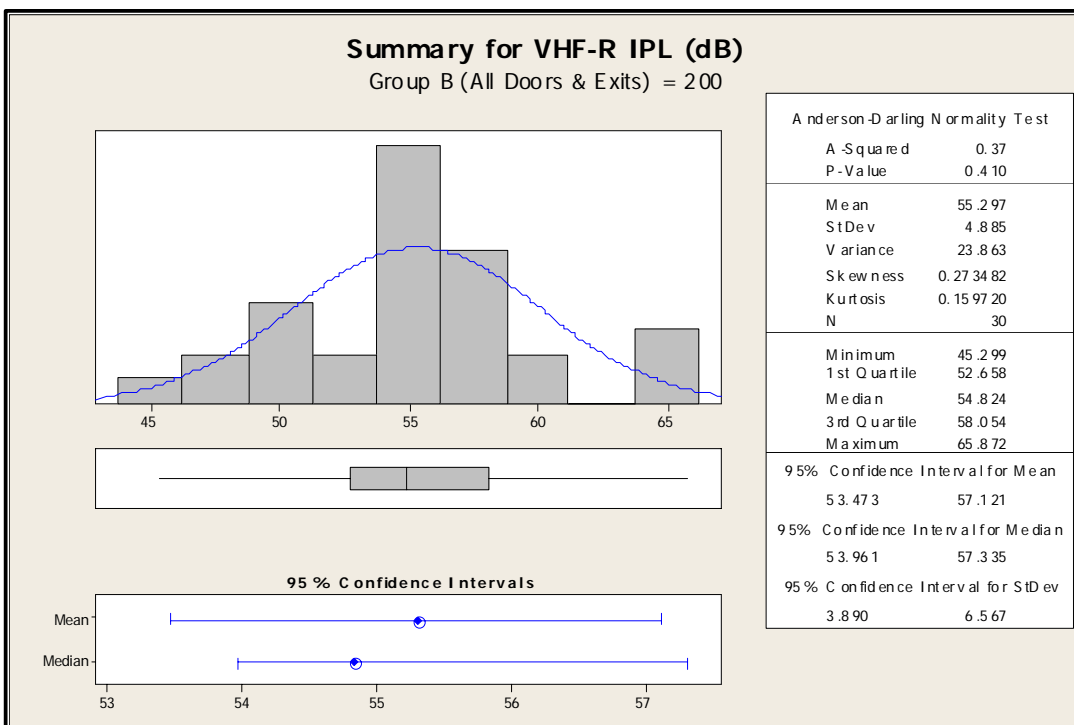


**Figure 1 - Grouping of EMI Data Measurements**

When the data was combined around Grouping B, the analysis revealed that more of the data could be classified as normal data. In particular, the data for the doors (series 200), for VHF-L, VHF-R, VHF-C, and GPS-L were normalized (Figures 2 - 5). The results for passing the normality test for series 201, 202, 203, and 204 varied between systems. This indicates that the sub-grouping of these areas should be different, before we can make valid inferences about the characteristics of those portions of the aircraft.

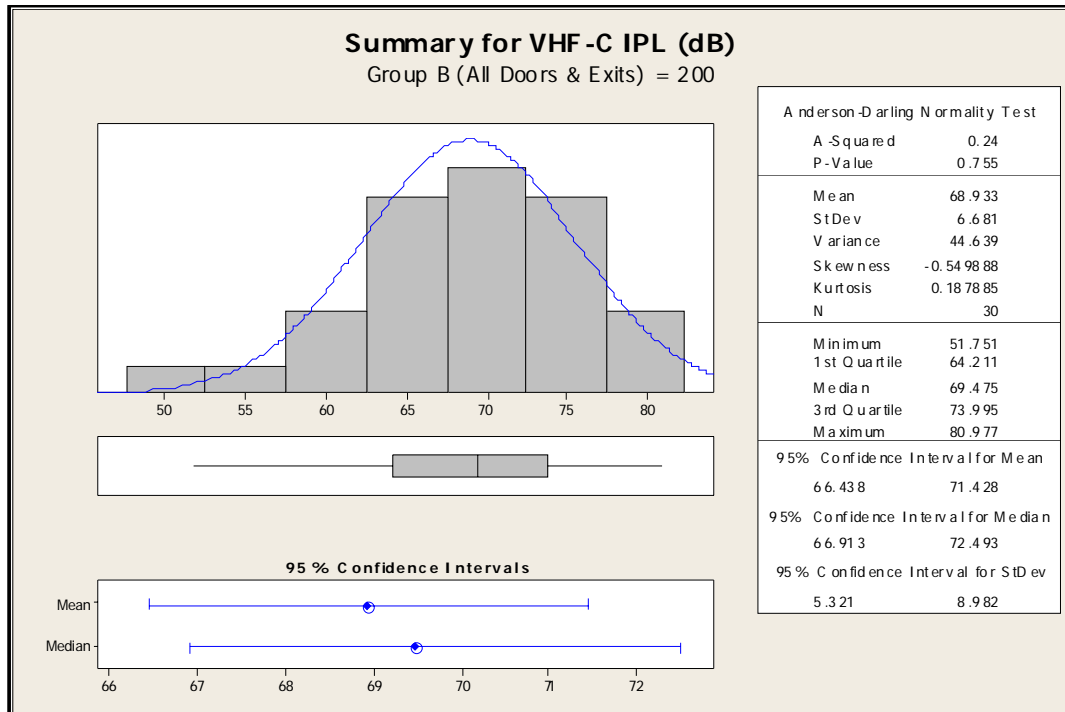


**Figure 2 - VHF-L Group B**

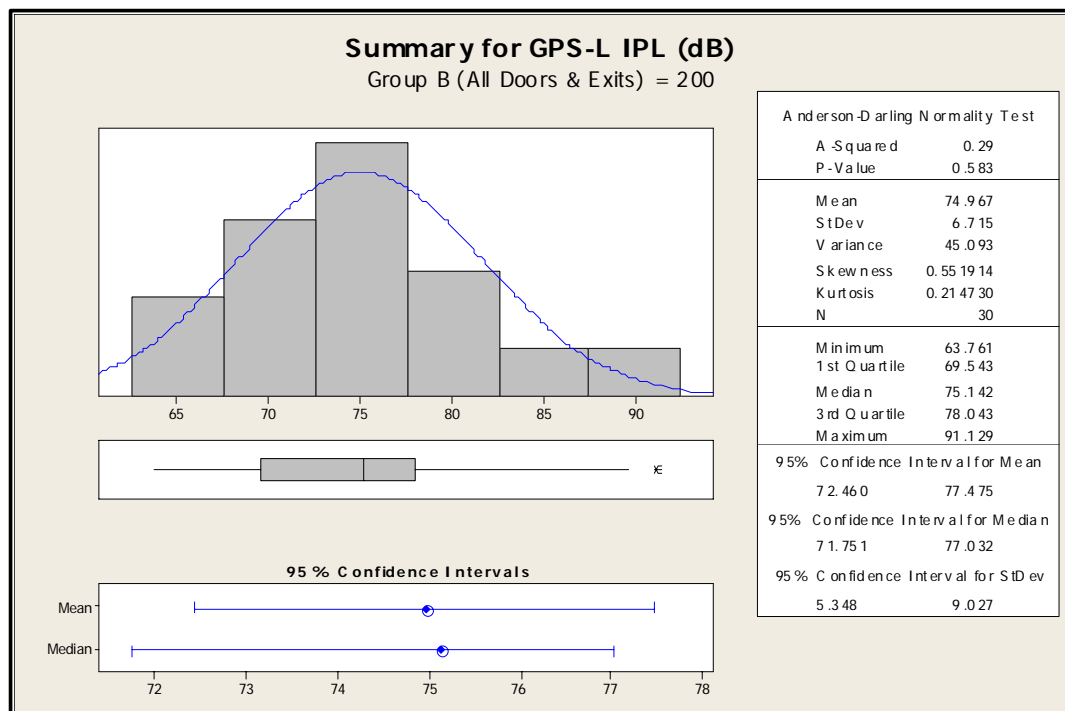


**Figure 3 - VHF-R Group B**





**Figure 4 - VHF-C Group B**



**Figure 5 - GPS-L Group B**

### 4.3 Hypothesis Testing of Door Data

One of the key goals of this study is to determine if the measurements taken to date can be inferred across the whole entire 757 fleet. By performing a T-Test (statistical test) between two independent sample statistics (i.e. the path loss of one aircraft compared to the path loss of another), we can determine with high probability whether the two statistics are similar. With a sufficient number of samples, we can infer the results across the entire population.

Knowing that we have normalized data for the doors, we performed T-Tests between aircraft. Given the following statistics, where the mean for an aircraft tail number =  $X_{\text{tail\#}}$ , we make a null hypothesis ( $H_0$ ) for each system and an alternate hypothesis ( $H_a$ ).

$$(2.1) \quad \begin{aligned} H_{0\text{VHF-L}} : X_{690} &= X_{6706} = X_{6707} \\ H_{a\text{VHF-L}} : X_{690} &\neq X_{6706} \neq X_{6707} \end{aligned}$$

$$(2.2) \quad \begin{aligned} H_{0\text{VHF-C}} : X_{690} &= X_{6706} = X_{6707} \\ H_{a\text{VHF-C}} : X_{690} &\neq X_{6706} \neq X_{6707} \end{aligned}$$

$$(2.3) \quad \begin{aligned} H_{0\text{VHF-R}} : X_{690} &= X_{6706} = X_{6707} \\ H_{a\text{VHF-R}} : X_{690} &\neq X_{6706} \neq X_{6707} \end{aligned}$$

$$(2.4) \quad \begin{aligned} H_{0\text{GPS-L}} : X_{690} &= X_{6706} = X_{6707} \\ H_{a\text{GPS-L}} : X_{690} &\neq X_{6706} \neq X_{6707} \end{aligned}$$

In general, a T-Test compares a sample to an ideal normal curve with an ideal standard deviation, the results of the comparison generates a probability value “P” or “P-value” that will have a value between 0 and 1. For a 95% confidence level, if the P-value  $> 0.05$ , we say that  $H_0$  is true, because enough data points from both statistics fall where the majority of points should fall in a normal curve. If the P-value  $\leq 0.05$ , then we say that  $H_0$  is not true and that  $H_a$  is true because a larger portion of data from both statistics fall in region where only 5% of the data should fall. This indicates that the results are significant enough that they cannot be equal. The results of the T-Test are shown in Table 1.

**Table 1 - Hypothesis Test for Door Statistics**

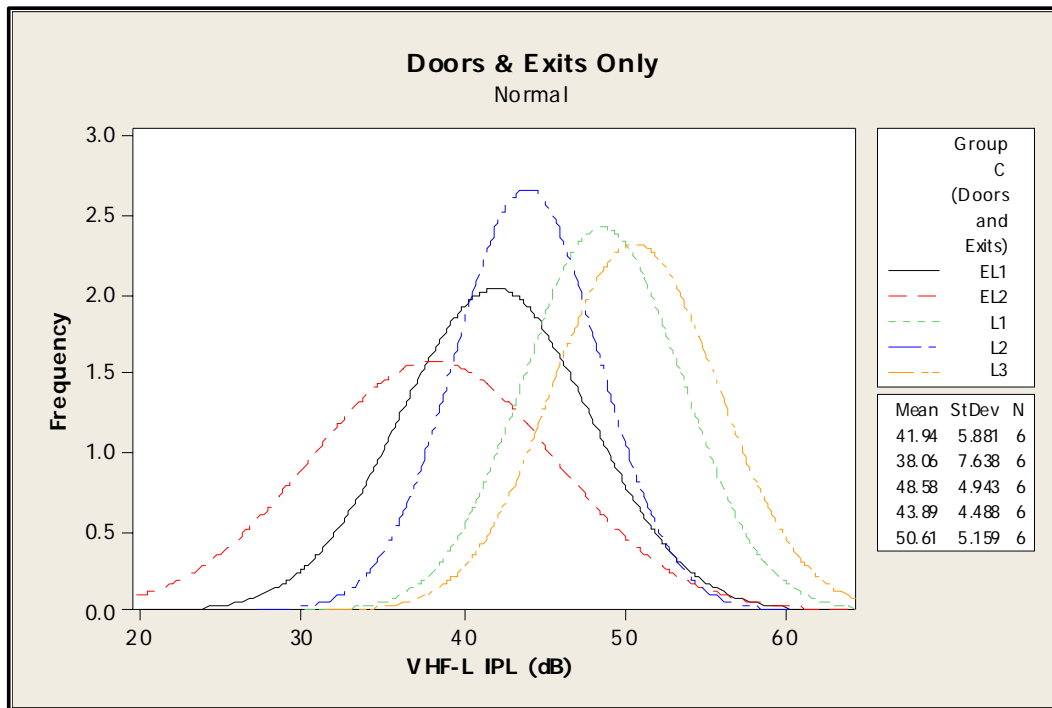
<b>System</b>	<b>Aircraft Means</b>	<b>P-Value</b>	<b>Result</b>
VHF-L	690 & 6706	0.688	Ho = True
VHF-L	6706 & 6707	0.511	Ho = True
VHF-L	690 & 6707	0.213	Ho = True
VHF-C	677 & 690	0.364	Ho = True
VHF-C	660 & 690	0.217	Ho = True
VHF-C	660 & 677	0.953	Ho = True
VHF-R	677 & 690	0.005	Ho = False
VHF-R	660 & 677	0.040	Ho = False
VHF-R	660 & 690	0.147	Ho = True
GPS-L	6707 & 6709	0.017	Ho = False
GPS-L	6706 & 6709	0.005	Ho = False
GPS-L	6706 & 6707	0.980	Ho = True

Based on the results in Table 1, we can infer with 95% confidence that the average minimum path loss at the doors and emergency exits (L1, L2, L3, EL1, and EL2) for the left and center VHF systems across all 757 aircraft will be:

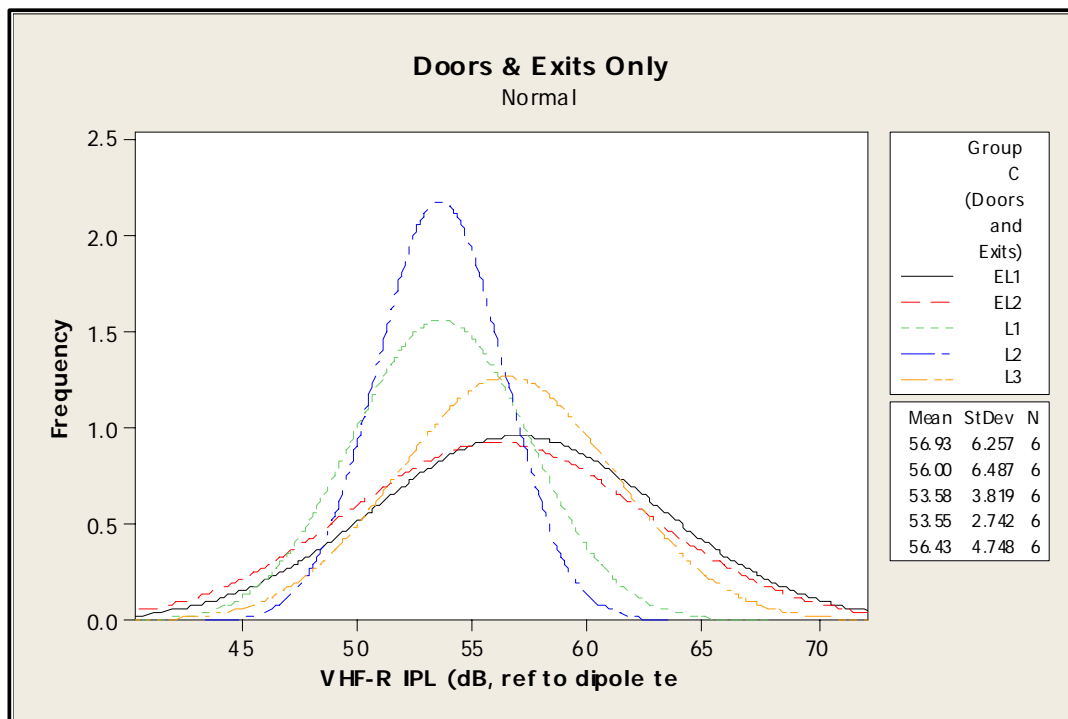
**Table 2 - Average Minimum Path Loss**

<b>System</b>	<b>Mean</b>	<b><math>\sigma</math></b>
VHF-L	44.61 dB	7.034 dB
VHF-C	68.93 dB	6.681 dB

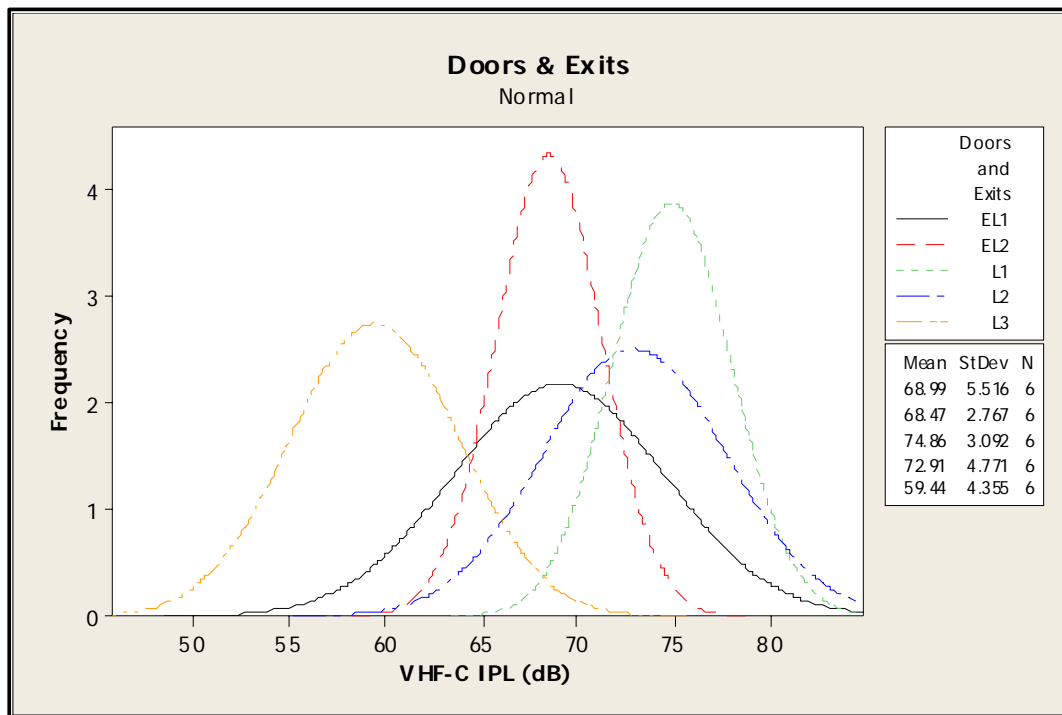
The worse case minimum path loss (23.52dB to 65.72dB) would be the VHF-L antenna, measured at any door, for any 757 aircraft. Factoring in errors within the data, the analysis shows, with a 95% confidence level, that the worse shift path loss mean would be 42 dB with a worse case standard deviation of 9.46 dB. In other words, factoring in error within the data, the worse case minimum path loss would be 14dB for VHF-1. Figures 6 through 8 show graphical representation for the distribution of path loss data at each door for each 757 VHF antenna.



**Figure 6 - VHF-L Door Distributions**

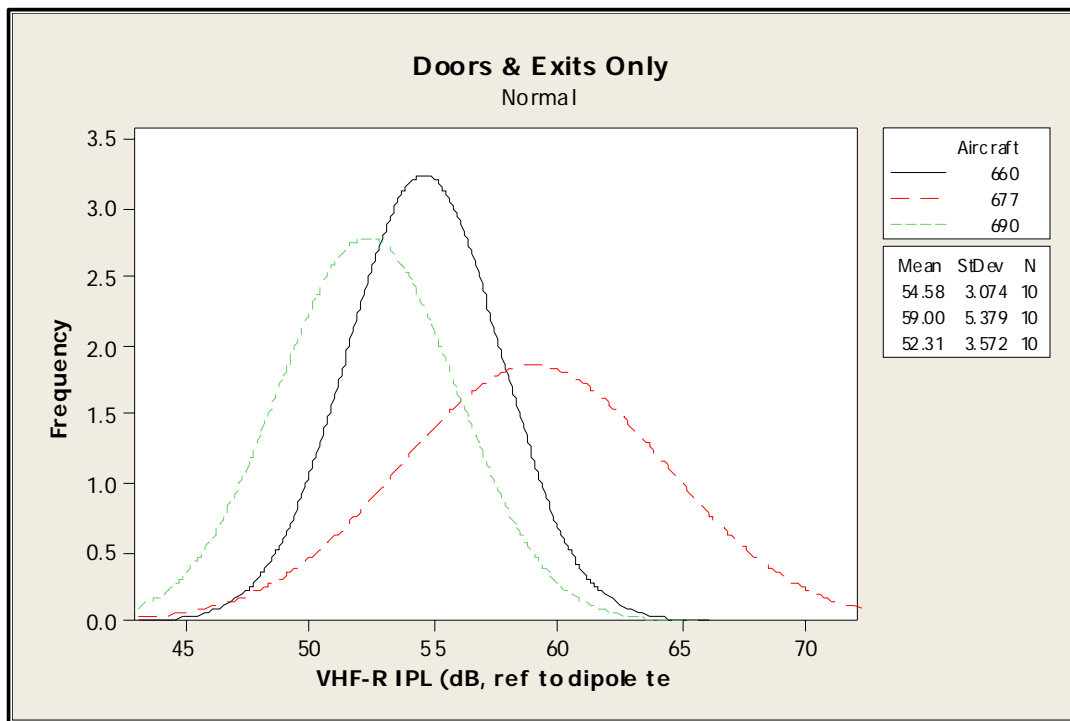


**Figure 7 - VHF-R Door Distributions**

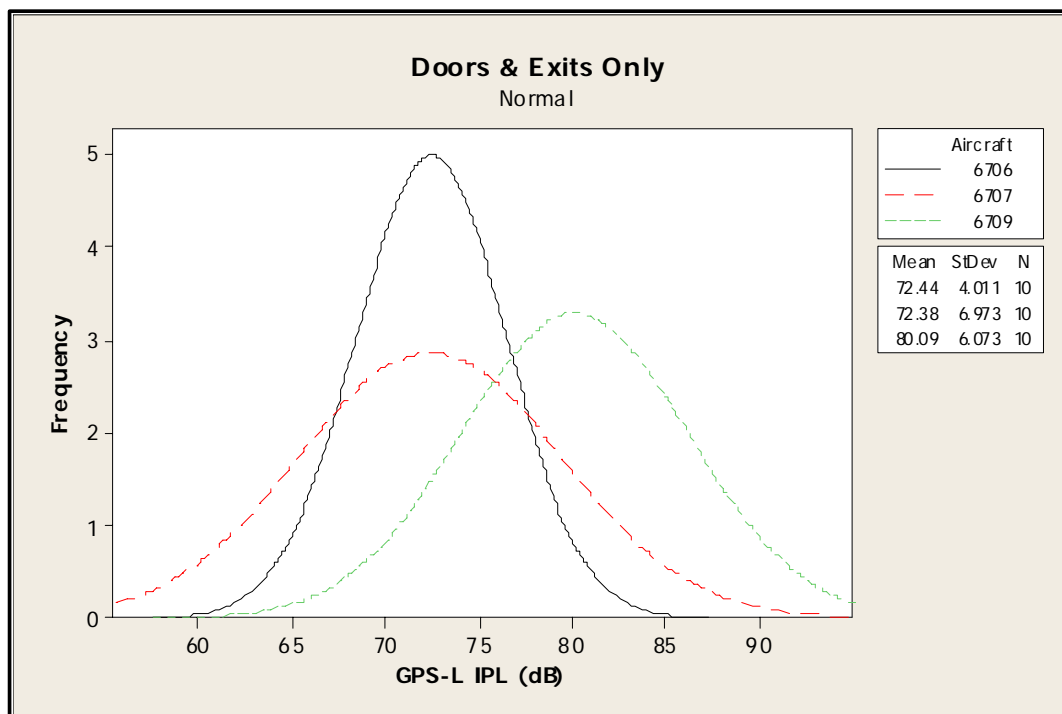


**Figure 8 - VHF-C Door Distributions**

The T-Test for the VHF-R and GPS antennas conclude that no inferences regarding door data can be made about similarities between aircraft. As Table 1 shows, two out of the three tests rejected the null hypothesis; therefore there is enough significant difference between the samples to infer that the doors and exits are not equivalent. Looking at Figures 9 and 10, you can see that means are dissimilar and some aircraft have a larger standard deviation.



**Figure 9 - VHF-R Distributions By Aircraft**



**Figure 10 - GPS-L Distributions By Aircraft**

These differences are probably due to the variation of unknowns discussed in section 4.2. When looking at the grand averages of all of the data it shows further dissimilarities between the three aircraft. Further analysis or measurements may be required to further characterize this data.

#### **4.4 Analysis of Window Data**

When analyzing the window data, in large groupings, the results have shown that the distributions are not normal. However, significant findings were observed with the VHF-L data. (Refer to Attachment 2 for plots of window data.) The linear plots of the antenna position (window) versus the path loss for each aircraft show that the aircraft are very similar. Yet the distribution plot show that the data is not normalized. To date, the grouping strategies have not yielded any significant results for the whole aircraft.

What is noticeable is the minimum path loss between the L2 door and the last emergency exit door. For VHF-L, this area seems to be the critical area for minimum path loss. The data between L2 and EL2 was extracted from the complete data set and analyzed for normalized data. For this portion of the aircraft, the data is normalized.

## **5 RESULTS AND CONCLUSIONS**

- As discovered in previous path loss measurement activities, over-wing emergency exit doors set the minimum path loss for VHF-L. These emergency exit doors also produce near-minimum path loss values for VOR and Localizer (reference charts in Attachment 2). 10 dB more signal margin can be obtained by simply moving two or three rows forward or aft of the emergency exit windows.
- Minimum interference path loss values measured were as follows:

**Table 3 - MIPL Values**

<b>System</b>	<b>MIPL (dB)</b>	<b>Test Antenna Gain (dB)</b>	<b>MIPL (dBd)*</b>
Marker Beacon	74	-19	55
Localizer	51	-13	38
VOR	60	-13	47
VHF-L	38	-11	27
VHF-R	47	-11	36
VHF-C	52	-11	41
Glideslope	53	-1	52
ATC Upper	46	5	51
ATC Lower	52	5	57
DME-L	47	5	52
DME-R	45	5	50
TCAS Upper	50	5	55
GPS	63	7	70

\* Table 3 includes measured data in two different units. The unit dBd means dB referenced to a dipole test antenna. NASA requested that the path loss data be corrected to dBd units. To convert from normal path loss units (dB) to dBd units, the gain of the transmitting test antenna is added.

- Despite our efforts to maintain consistency in test setup and procedures, data varied more than expected from one aircraft to the next. For example, the Glideslope chart in Attachment 2 shows path loss for aircraft 6707 with a different slope and shape than that of the other two aircraft.
- Performing path loss measurements on operational aircraft, even during overnight layovers, is quite challenging. Often, maintenance personnel are addressing several issues on the aircraft anytime it is on the ground. It is a delicate balance to accommodate the needs of maintenance personnel and the requirements for path loss testing at the same time.

## **6 RECOMMENDATIONS**

- Measured path loss data from this task should be compared to computer modeling software path loss predictions.
- Further work should be done regarding emergency exit doors. For comparison purposes, path loss data should be collected on another operator's 757 aircraft that do not have over-wing type emergency exit doors. For instance, US Air has 757s with a small door aft of the wing instead of over-wing exits.



- The GPS minimum path loss value (63 dB) measured for this effort should be included in RTCA SC-202's table of path loss data.
- This data should be used by airframe manufacturers in order to make comm/nav systems more resistant to PED emissions.
- Minimum path loss values should be used to recommend aviation-friendly FCC Part 15 emission limits.
- Path loss data should be collected on a new generation aircraft, such as the 767-400, that currently has no path loss data.

# ATTACHMENT 1

## Interference Path Loss (IPL) Measurement Procedure

<u>Table of Contents</u>	
	<u>Page</u>
1. <i>Parts Required for Measurements</i> .....	1
2. <i>Overview of IPL Measurements</i> .....	2
3. <i>Instrumentation Hook-up/Set-up</i> .....	3
4. <i>Test Cable Loss (TCL) Measurements</i> .....	5
5. <i>IPL Measurements</i> .....	6
6. <i>Appendices</i> .....	8

The following procedure may be used to successfully complete IPL measurements on an airplane.

### 1. *Parts Required for Measurements:*

The following instruments and cables are required to perform IPL measurements:

- Laptop Computer with *HP VEE Path Loss Measurement Software*.
- Spectrum Analyzer. Used *Agilent E4407B ESA-E Series Spectrum Analyzer* in this write-up.
- Calibration Cable
- Power Amplifier with SMA Power-Amp Cable and Power Supply
- 2 Coaxial cables for Aircraft Antenna and Transmit Antenna
- Transmitting Antenna (i.e. Biconical, Dipole, Horn etc.)



Figure 1: IPL Measurement Equipment

## 2. Overview of IPL Measurements:

IPL data is taken by radiating a low powered continuous wave (CW) test signal, frequency-synchronized to the spectrum analyzer sweep and fed to the test transmitting Antenna via a double-shielded RF cable. The spectrum analyzer, laptop computer controller, RF Amplifiers and preamplifiers are located inside the aircraft. The spectrum analyzer input cable is connected to the aircraft radio receiver rack cable in the avionics equipment bay.

To perform an IPL measurement, the radio frequency (RF) power loss is measured between the calibrated signal source and a spectrum analyzer, via the entire length of test cables plus the aircraft cable, plus the free space loss between the reference antenna and the aircraft antenna.

$$\alpha_{\text{GSE/AC/FS(dB)}} = [P_{\text{Xmt(dBm)}} - P_{\text{Meas(dBm)}}]_{\text{GSE/AC/FS System Loss}}$$

The IPL is the power difference between the CW test source radiated power level and the power level received at the point of entry into the aircraft radio receiver. Two types of data are collected: fixed location data at windows, seats, and aisles, and sweep data along the seams of doors, cockpit windows, hatches, and emergency exits. All data is taken in both horizontal and vertical polarization (Fuller [1]). Figure 2 provides a description of the test setup. To obtain a calibrated IPL measurement, test cable losses were measured separately by connecting ends (1) and (2) together, and subtracting this loss, in dB, from the raw measurement.

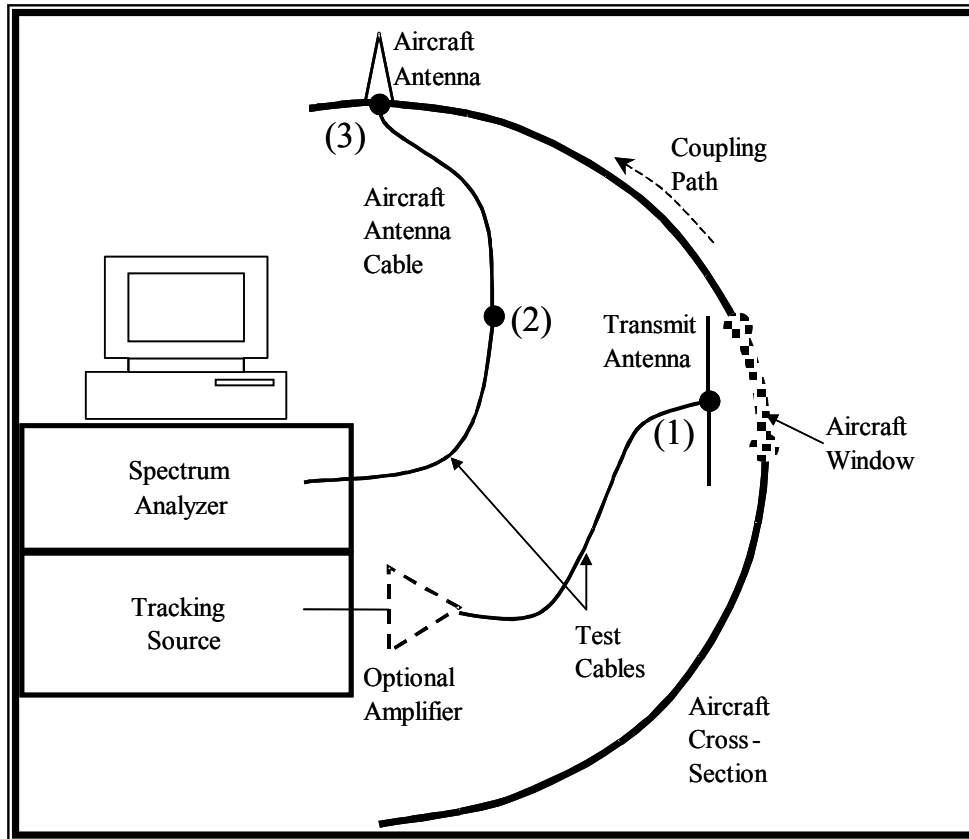


Figure 2: Test Set-up

### 3. *Instrumentation Hook-up/Set-up:*

#### A. *Laptop Computer:*

In the testing procedure, laptop will be used to capture screen shots from the spectrum analyzer as well as for storing data.

1. After powering up the laptop using the power supply, enter the username and password. (sticker on computer keyboard)
2. From desktop, launch “*PathLossMeas\_SA\_AutoDownload\_ver3.0.1*” by double clicking on the icon.

#### B. *Spectrum Analyzer:*

1. As shown in Figure 3, connect the 120VAC cable to the spectrum analyzer.

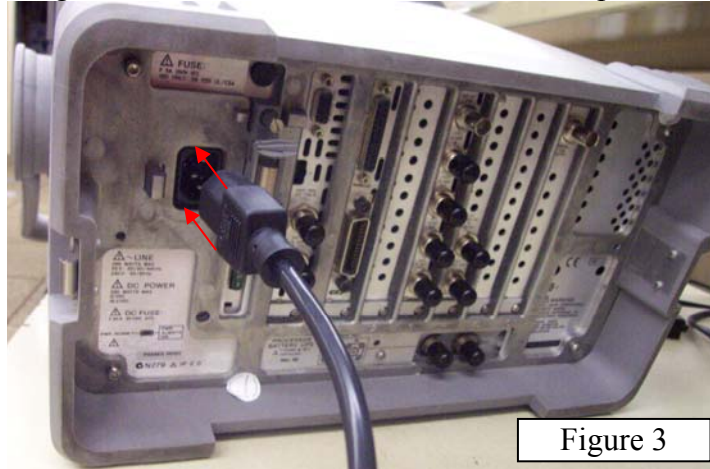


Figure 3

2. Using the National Instruments GPIB cable, connect laptop's PCMCIA-GPIB card (National Instruments) with the spectrum analyzer's HP-IB parallel port. Please refer to Figure 4.

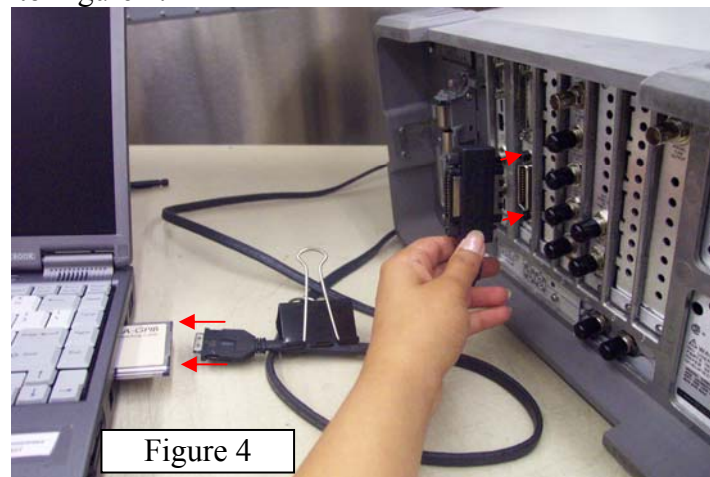


Figure 4

#### C. *Set-up of Spectrum Analyzer:*

1. Turn the Spectrum Analyzer on by using the power button on the lower left corner on the front panel.
2. Let the Spectrum Analyzer perform initial alignments automatically.
3. Calibrate the Spectrum Analyzer by using the Calibration cable shown in Figure 5.

- a. Connect one end of the calibration cable to “Input 50Ω” while the other end to “AMPTD ref out” connector on the front panel of the spectrum analyzer.
- b. Go to “Systems”<sup>1</sup> → “alignments”<sup>2</sup> → “align now” → “All”

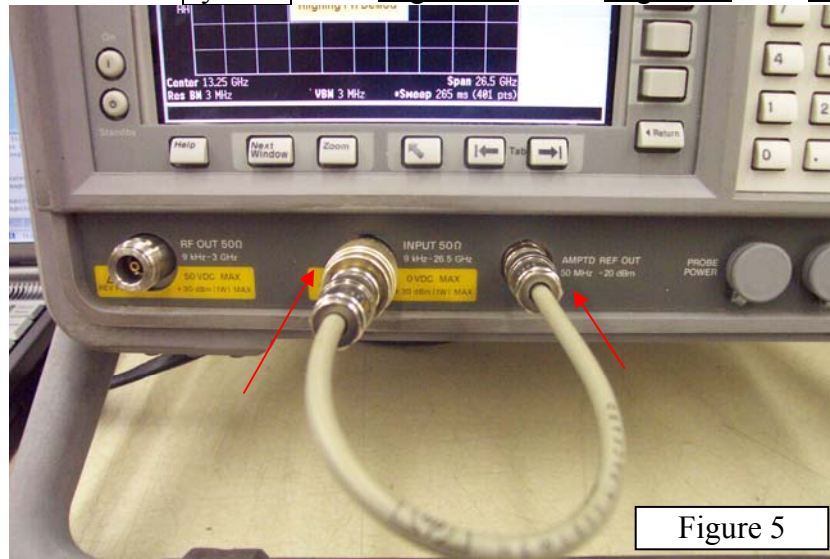


Figure 5

#### D. Capturing Data on Laptop Computer:

This procedure is used for TCL measurements (Section 4) and IPL measurements (Section 5). Please refer to the screen shot in Figure 6 on the next page.

1. Click the Run Icon (▶) to start the program. On the original screen (in Figure 6), observe that the software should have identified the type of spectrum analyzer connected to the system (in this case, “E4407B” on the right hand column).
2. Begin by clicking on the check box next to “Enter Data Dir & Filename Root”. In the pop-up directory, find the folder named “Delta IPL 7\_04” which will be used to store all data collected during testing. Open “Delta IPL 7\_04”, enter test name and click “save”.
3. Click on the check box next to “Change File Index Number” whenever it needs to be set. Initially, indexing begins at 1, and automatically increments upon each recording; therefore, use this feature if an erroneous measurement was occurred and data needed to be retaken.
4. Finally, click on the check box next to “Download & Record Trace”. This step should result in the capture of the screen currently on the spectrum analyzer (after “View/Trace” → “ClearWrite” → “Peak Search” was performed on the spectrum analyzer). Observe that the software confirms the start and stop frequency as well as records the maximum frequency measured by the spectrum analyzer, denoted by “Marker Amp” (in this case, -11.16 dBm).

<sup>1</sup> Boxed names refer to physical soft buttons found on the *front panel* of the Spectrum Analyzer

<sup>2</sup> Underlined names refer to options available on the *display screen* of the Spectrum Analyzer.

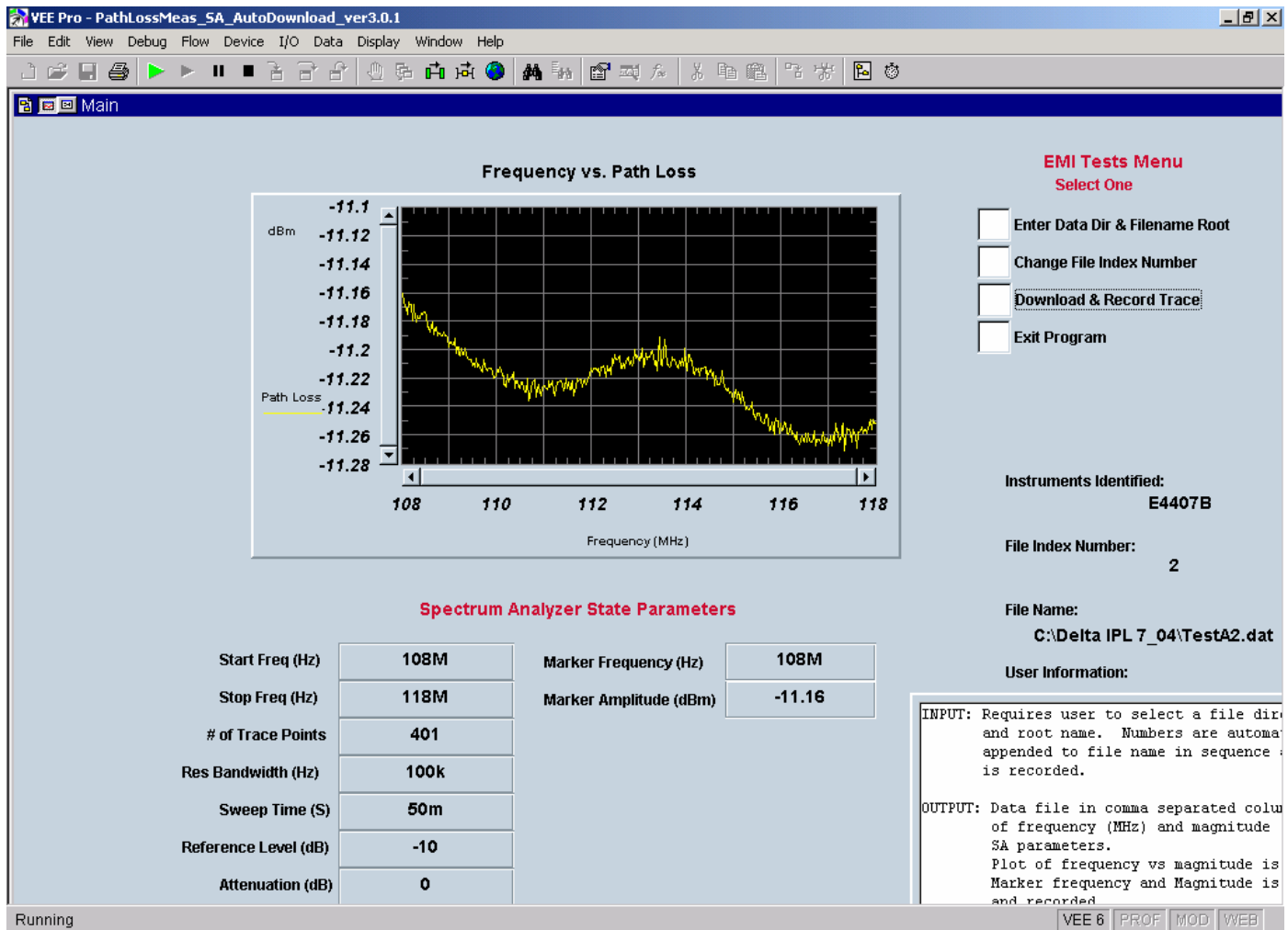


Figure 6

#### 4. Test Cable Loss (TCL) Measurements:

TCL Measurements are necessary to observe the power loss incurred in the double shielded RF Cables. This procedure must be performed every time for each system of the aircraft during testing, i.e. VHF, TCAS etc.

- A. Set the Start and Stop frequencies for the system of concern. Please refer to the table below for aircraft systems and their frequency bands.

Aircraft Systems	Frequency Bands
MB	74 – 76 MHz
VHFCOM	116 – 138 MHz
VOR	108 – 118 MHz
LOC	108 – 113 MHz
GS	325 – 340 MHz
DME	960 – 1215 MHz
TCAS	1080 – 1100 MHz
ATC	1020 – 1040 MHz
GPS	1565 – 1585 MHz

For example, VOR ranges from 108 MHz to 118 MHz:

- Go to “Frequency” → “Start Freq” → “1 0 8” → “MHz” to set starting frequency.
  - Similarly, go to “Stop Freq” → “1 1 8” → “MHz” to set the stopping frequency.
- B. Turn the Source on by going to “Source” → “on”. Make sure that the Source “Amplitude” is –10 dBm. If not, then change to “1 0” → “dBm”
- C. Set the reference to 0 dBm and attenuation to “auto” by going to “Amplitude” and changing the “Ref” to “0” → “dBm”; and “Atten” to “Auto” on the display screen.
- D. Go to “View/Trace” → “ClearWrite” to begin the tracing of the signal on the spectrum analyzer.
- E. Perform peak search to calculate and record the TCL Measurement by pressing “Peak Search”.

$$\text{TCL Measurement} = \text{Source Amplitude} - (\text{result})$$

Where the Source Amplitude was set to –10 dBm in this case, and the “result” is found from the peak search above. Therefore, if the “result” was –11.19 dBm, then  $\text{TCL} = -10 - (-11.19) = 1.19 \text{ dBm}$ .

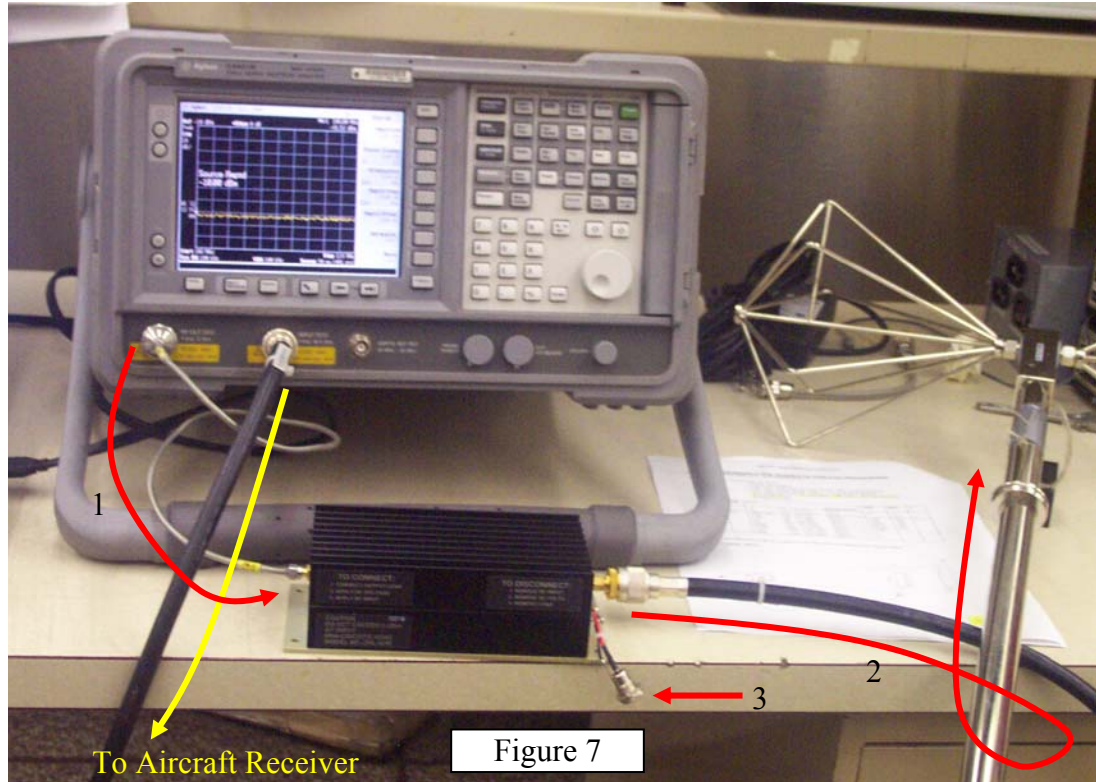
#### 5. IPL Measurements:

The following connections are necessary to perform the IPL measurements:

- A. *Spectrum Analyzer to Transmitting Antenna using a Power Amplifier:*
1. Using Figure 7 as a summary, connect an SMA Power-amp cable from “RF out 50Ω” connector on the spectrum analyzer to the input of the Power Amp.
  2. Then connect a double-shielded RF cable from the output of the Power-amp to the transmitting antenna.



3. Connect the power supply to the power-amp<sup>\*\*\*</sup>.



B. *Spectrum Analyzer to aircraft Receiver in the Avionics Bay:*

Connect a double-shielded RF cable from the “Input 50Ω” connector of the spectrum analyzer to the aircraft antenna, usually (via the receiver rack) in the avionics bay.

Before proceeding to measuring and recording IPL Measurements, make sure to change the following settings on the spectrum analyzer:

Go to “Source” → “Amplitude” → “10” → “-dBm”. Also make sure that the “Ref” under “Amplitude” is “-10 dBm” while the “Atten” is “0 dBm Manual”.

*Side Note:* The source amplitude is set to  $-10$  dBm because the power amplifier ZHL-42W (see appendix for spec-sheet”) has a gain of approximately 37 dB across all the frequencies possible. The power amplifier also only has a Power Output capability of only around 27 dBm. Therefore, to make sure that the actual power output remains less than 27 dBm (which can possibly be as high as 37 dBm), we set the source amplitude to  $-10$  dBm, instead of leaving it at 0 dBm.

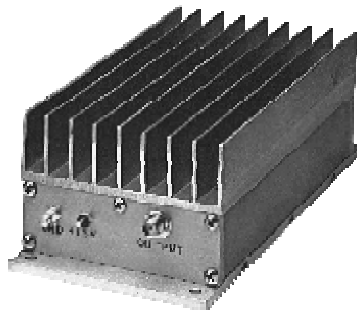
Take IPL Measurement by going to “View/Trace” → “ClearWrite” and performing “Peak Search”

\*\*\* **CAUTION!:** Make sure that steps 1 and 2 above are performed before performing this step!\*\*\*



## RF Amplifier

The RF amplifier used was a Mini-Circuits ZHL-42W. Specifications may be found at: <http://www.mini-circuits.com/cgi-bin/spec?cat=amplifier&model=ZHL-42W&pix=u36.gif&bv=4>



From manufacturer Specifications:

<u>Aircraft Band</u>	<u>Gain (dB)</u>
MB, VHF Com, VOR, LOC, GS	37.0
ATC, TCAS, DME	37.5

## File Notation for Path Loss Measurements

Filename:=     AAA BBB CCC DDD X.DAT

Where:    AAAA        = Aircraft Type (B757, etc.)  
              BBBB        = Aircraft Tail Number  
              CCC         = MB, VOR, LOC, VHF Com, GS, ATC, TCAS, GPS  
                               (Aircraft System)  
              DDD         = LWR, UPR, NOSE, GEAR, TAIL (Antenna Position)  
              EEE         = TCL, 1ML, APL, ACL, UWB, SBS (Test Cbl Loss, 1 Meter Loss, Aircraft Path Loss,  
                               Spectral Band Survey)  
              X             = File Index Number

AAAA	BBBB	CCC (Default RBW)			DDD	EEE	X
B757	???	MB	74 - 76 MHz	(RBW=_____)	LWR	TCL	1 - ?
		VHFCOM	116 - 138 MHz	(RBW=_____)	UPR	1ML	
		LOC	108 - 113 MHz	(RBW=_____)	NOSE	APL	
		VOR	108 - 118 MHz	(RBW=_____)	GEAR	SBS	
		GS	325 - 340 MHz	(RBW=_____)	TAIL		
		DME	960-1215 MHz	(RBW=_____)			
		ATC	1020 - 1040 MHz	(RBW=_____)			
		TCAS	1080 - 1100 MHz	(RBW=_____)			
		GPS	1565 - 1585 MHz	(RBW=_____)			

A sub-directory structure will be created on all test-control computers according to the plan:

C:\Delta IPL 7\_04\

## **Reference Sheet for NASA Instrumentation Setup**

### ***A) Steps for Each Day***

- 1) Position and set up equipment.
- 2) GROUND AIRCRAFT TO 120VAC REFERENCE.
- 3) GROUND SPECTRUM ANALYZER TO AIRCRAFT.
- 4) Hook-up and Boot computer. Turn on Spectrum analyzer.
- 5) Calibrate Spectrum Analyzer and Tracking Generator with Cal cable.
- 6) Verify Spectrum Analyzer GPIB Address 18
- 7) Launch HPVEE: PathLossMeas\_SA\_AutoDownload\_ver3.0.1xx.vee

### ***B) Steps for Each Aircraft System***

- 1) Select aircraft system and start **Log Page** in binder.
- 2) Hook up for measurement type & record on **Log Page**:
  - a) TCL: Test Cable Loss
  - b) 1ML: 1 Meter Loss
  - c) APL: Aircraft Path Loss
  - d) ACL: Aircraft Cable Loss
  - e) UWB: Ultrawideband
  - f) SBS: Spectral Band Survey
- 3) Record RF path variables on **Log Page** (Cable ID's, Pre-amps, DC blocks, Bias-tees, etc.)
- 4) Spectrum Analyzer
  - a) Set Frequency Range
  - b) Set for Non-Offset Tracking (if path loss meas.)
  - c) Set Source Output Level & record on **Log Page** (E4407B= -10dBm)
  - d) Set Pre-amp ON/OFF & record on **Log Page** (E4407B path loss meas. only).
- 5) Enter Filename Root information on computer & record on **Log Page**

### ***C) Steps for Each Path Loss Measurement Location***

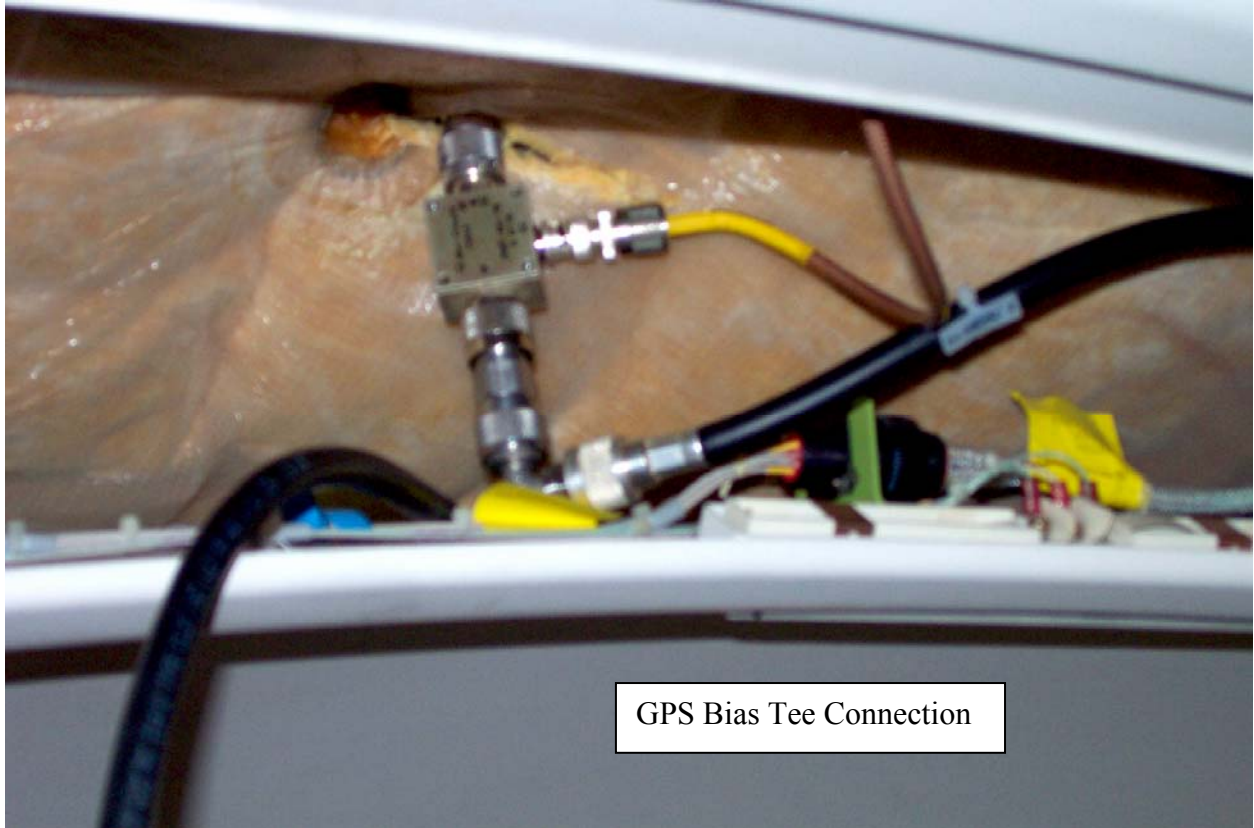
- 1) Set File Index # & record on **Log Page**
- 2) Confirm Antenna Position with assistant
- 3) Clear Trace
- 4) Max Hold
- 5) Peak Search
- 6) Adjust marker, if necessary
- 7) Download Trace to Computer
- 8) Record maximum amplitude on **Log Page**

## EMI Coupling Path Test Data Sheet

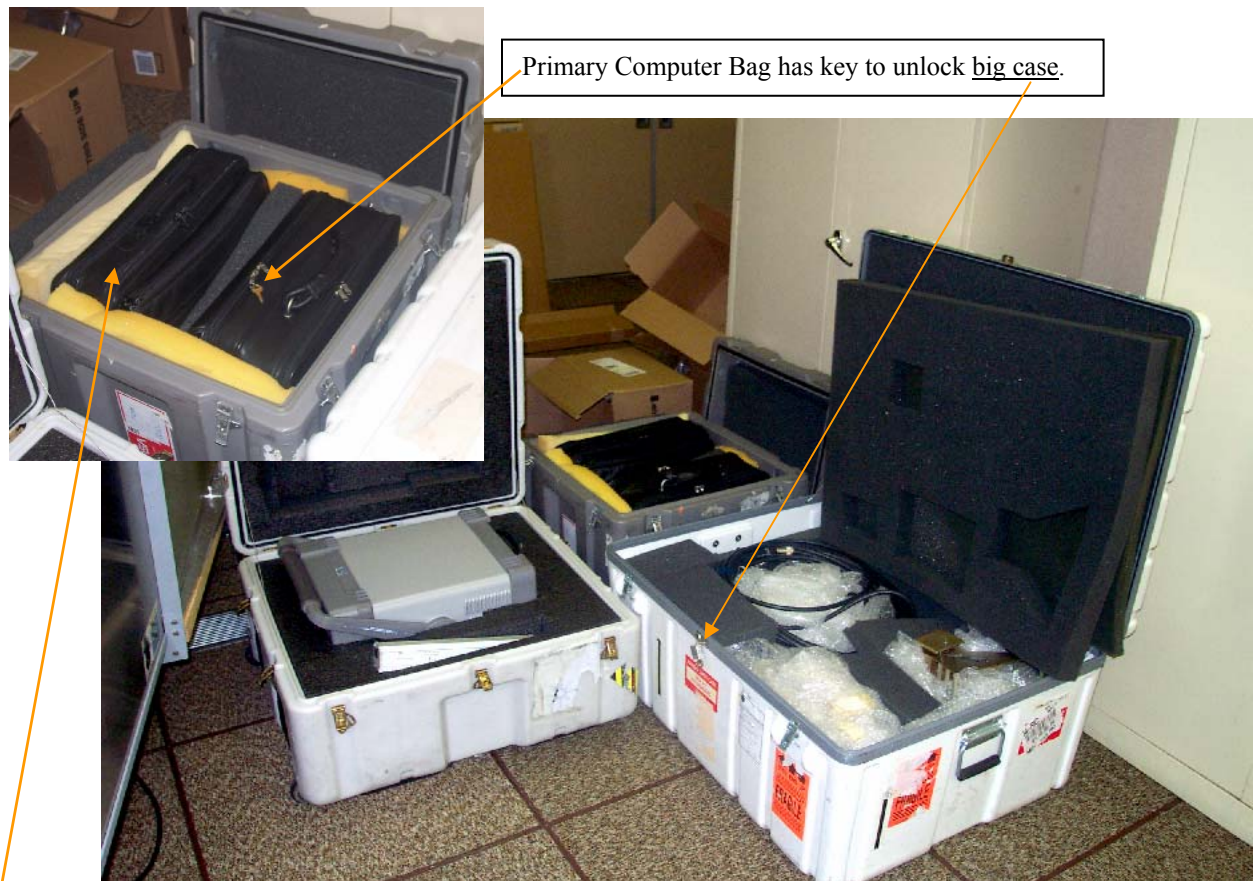
TEST NAME: \_\_\_\_\_ DATE: \_\_\_\_\_ LOCATION: \_\_\_\_\_ AIRCRAFT: \_\_\_\_\_

TEST TEAM: \_\_\_\_\_

File Index #	A/C Rcvr/ Ant. #	Tx Ant Position	Meas. Type (TCL,IML APL,ACL)	Tx Ant. Type	Tx Ant. Pol (H/V)	Tx Pwr. (dBm)	Pre Amp/ Pwr Amp	Rcv Pwr. (dBm)	Cable ID's	Comments or Special Conditions



GPS Bias Tee Connection



Primary Computer Bag has key to unlock big case.

Backup computer and equipment.

## ATTACHMENT 2

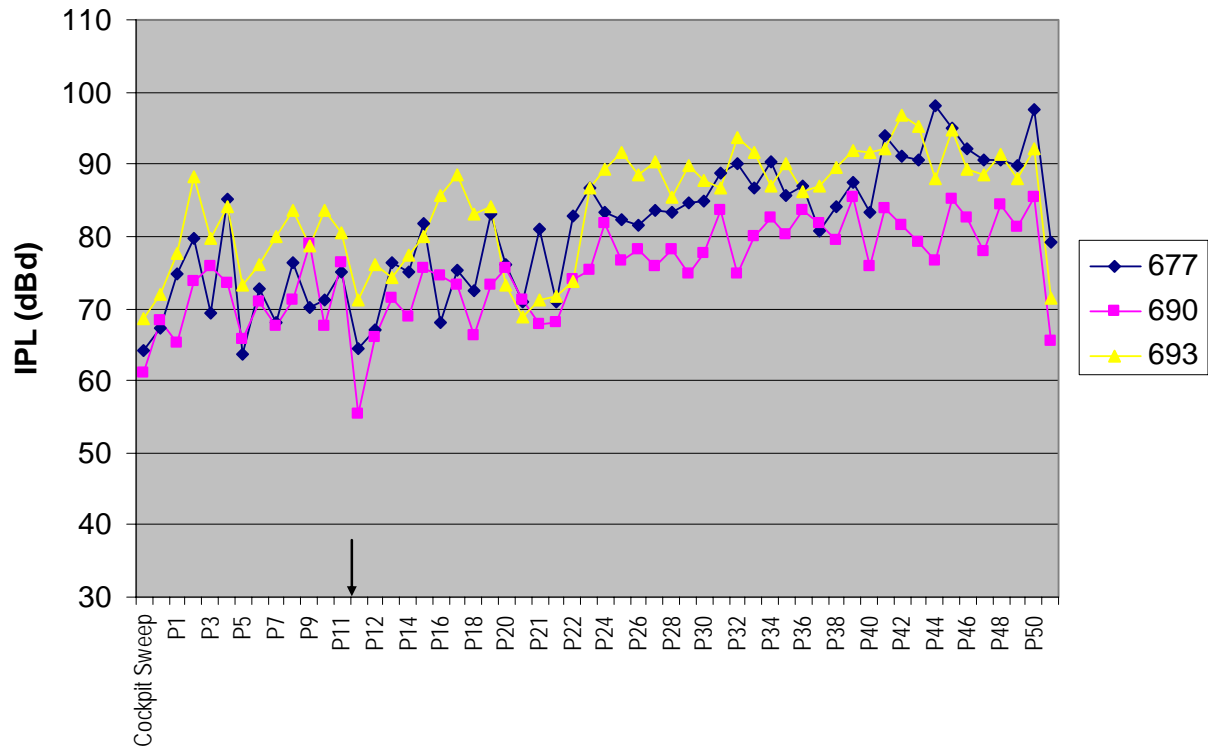


Figure 1 - Marker Beacon

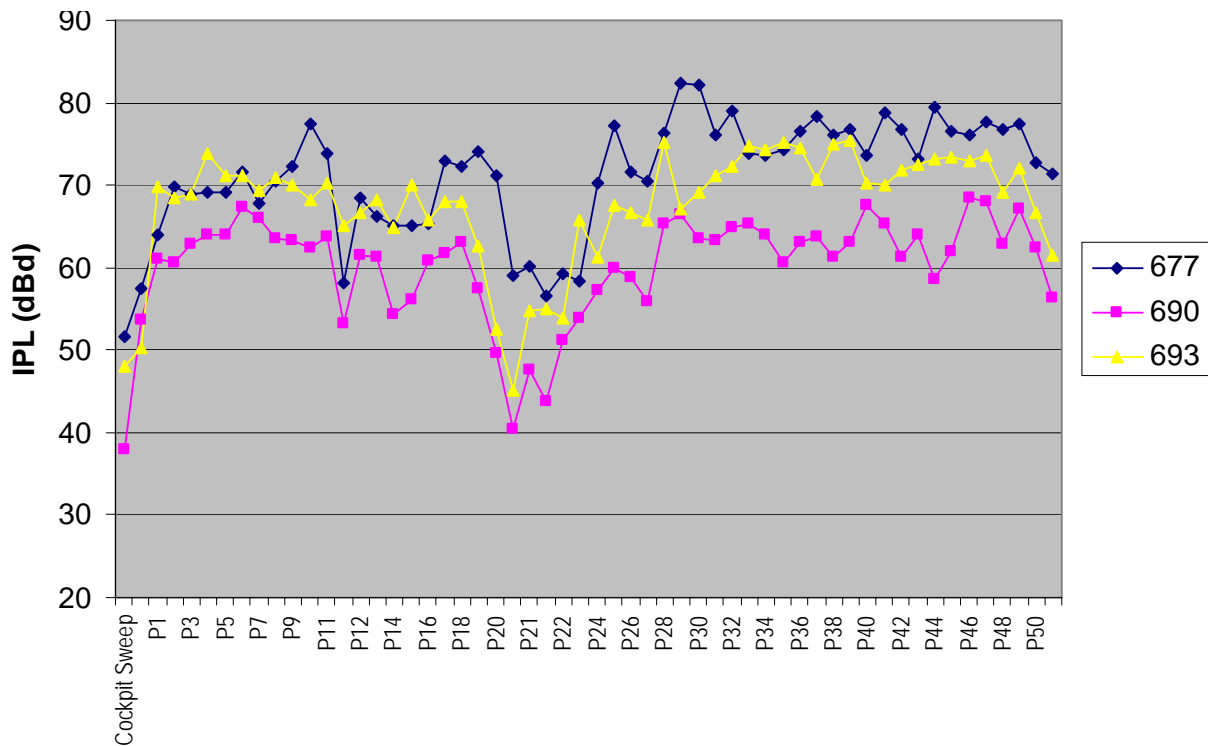


Figure 2 – Localizer

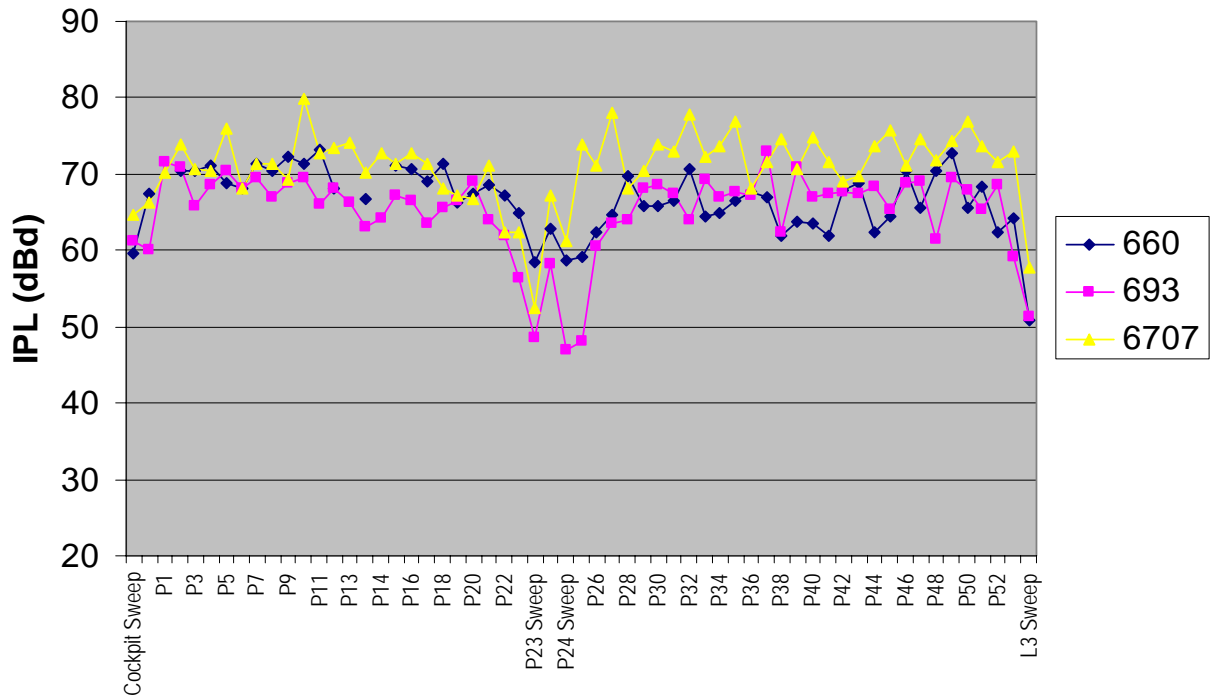


Figure 3 – VOR

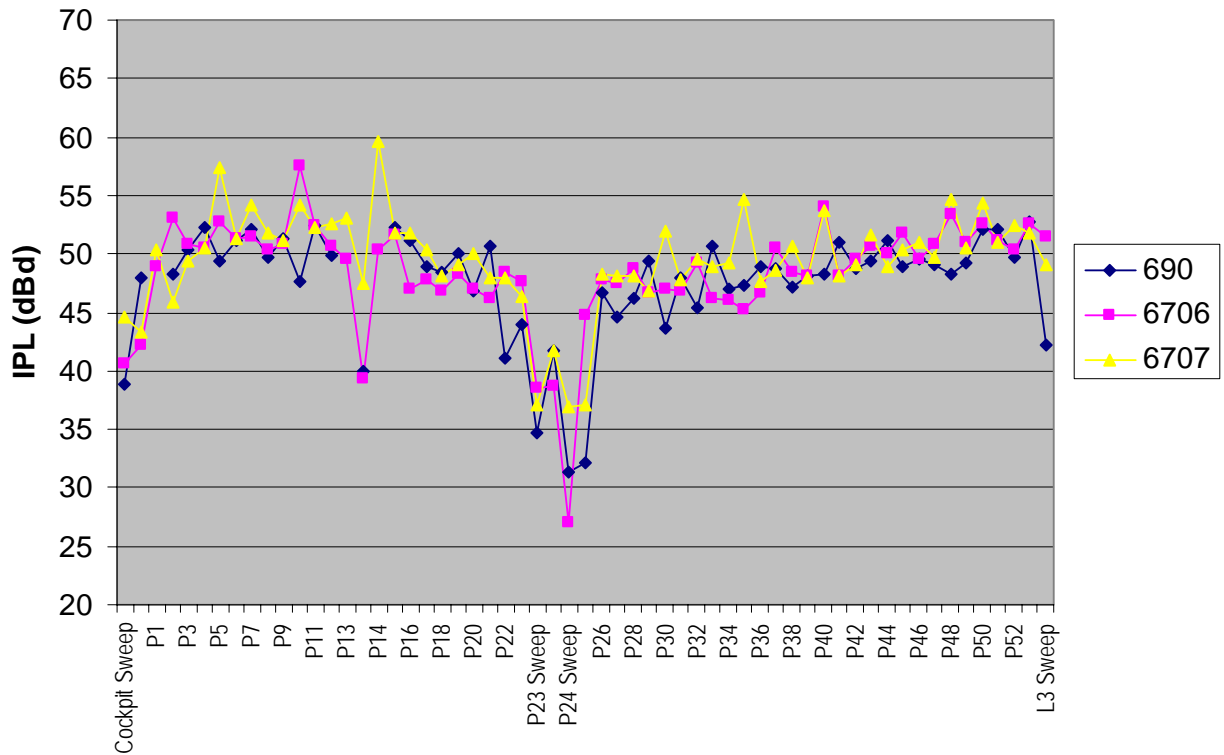
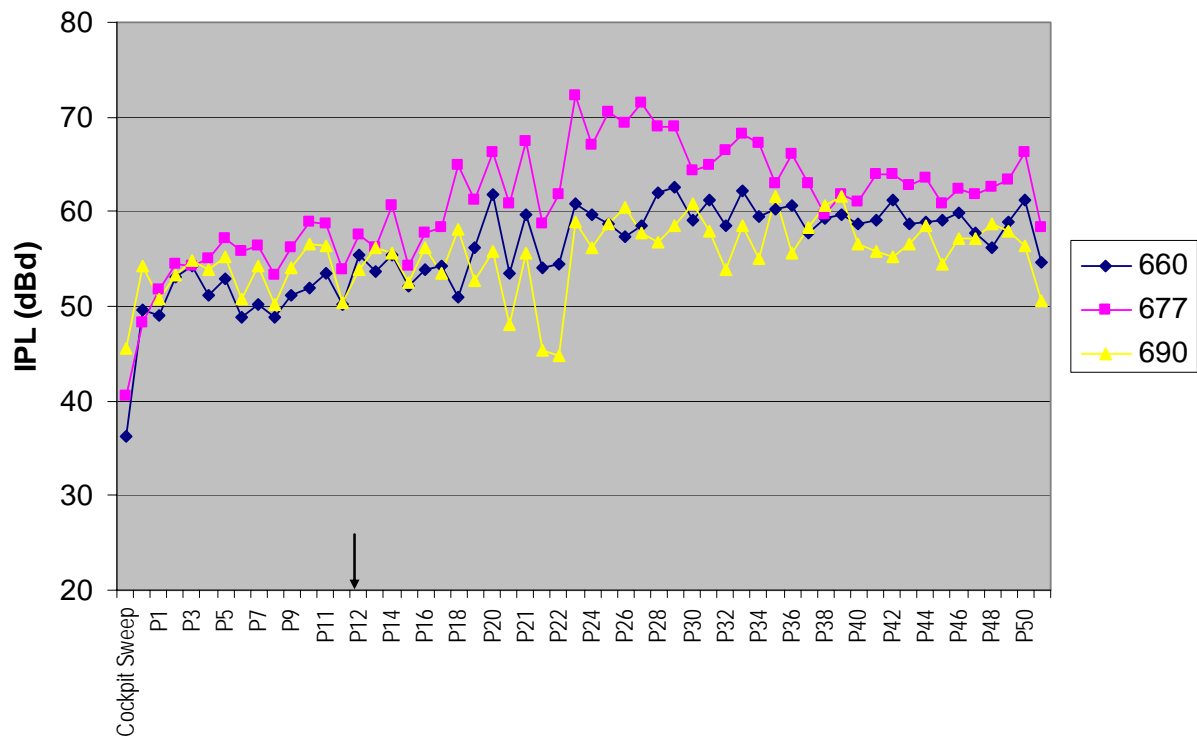
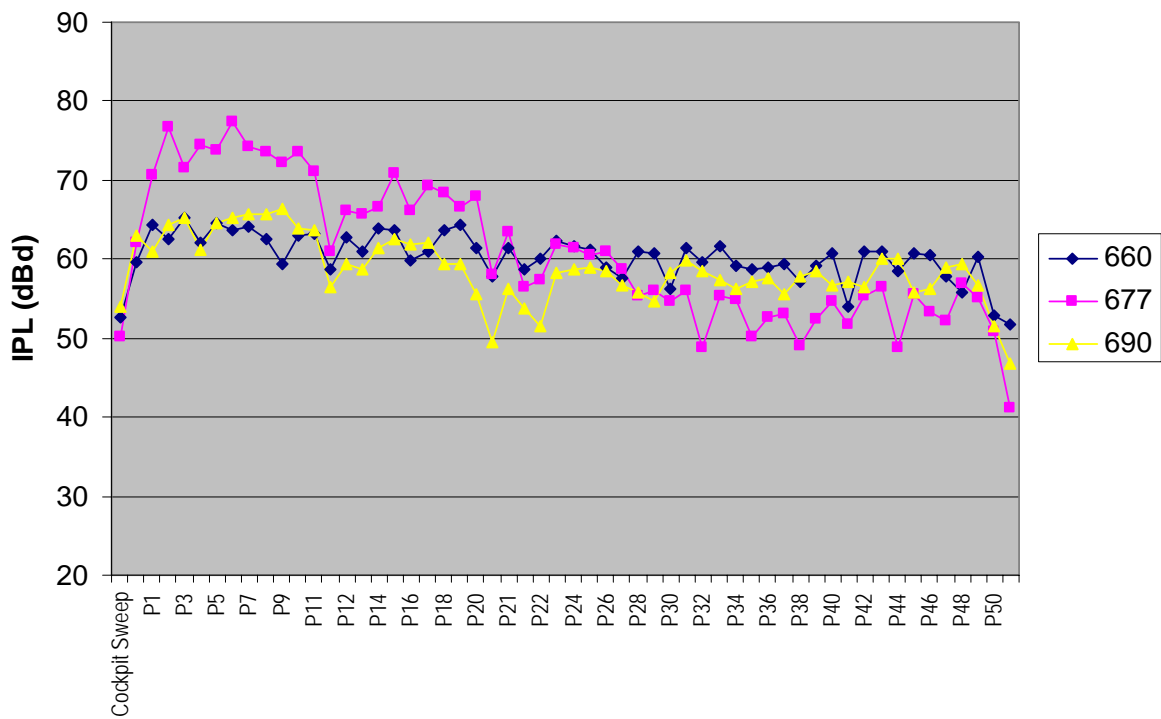


Figure 4 - VHF-L

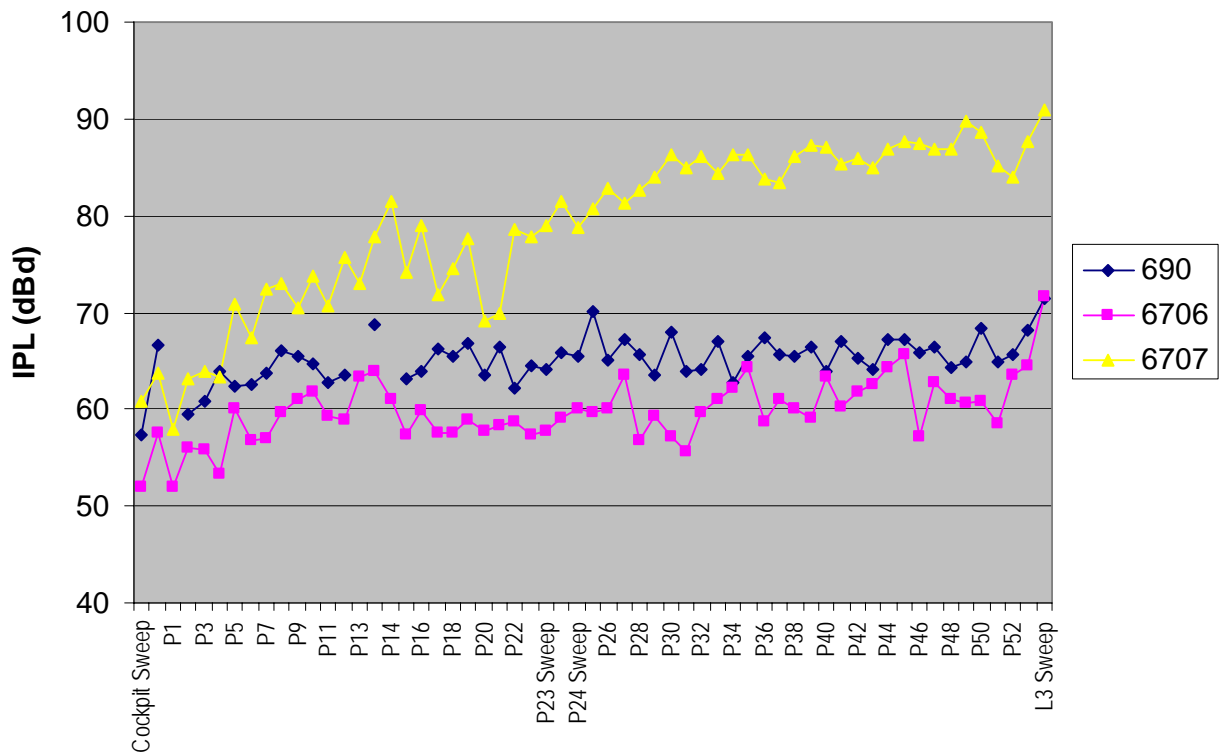


**Figure 5 - VHF-R**

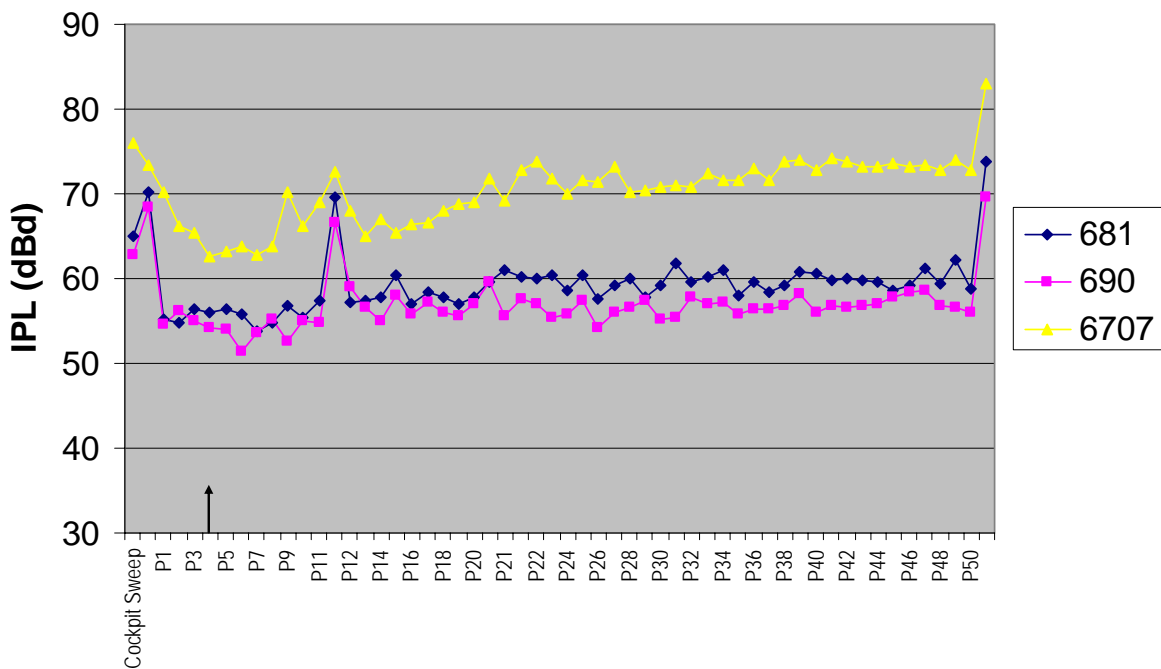


**Figure 6 - VHF-C**

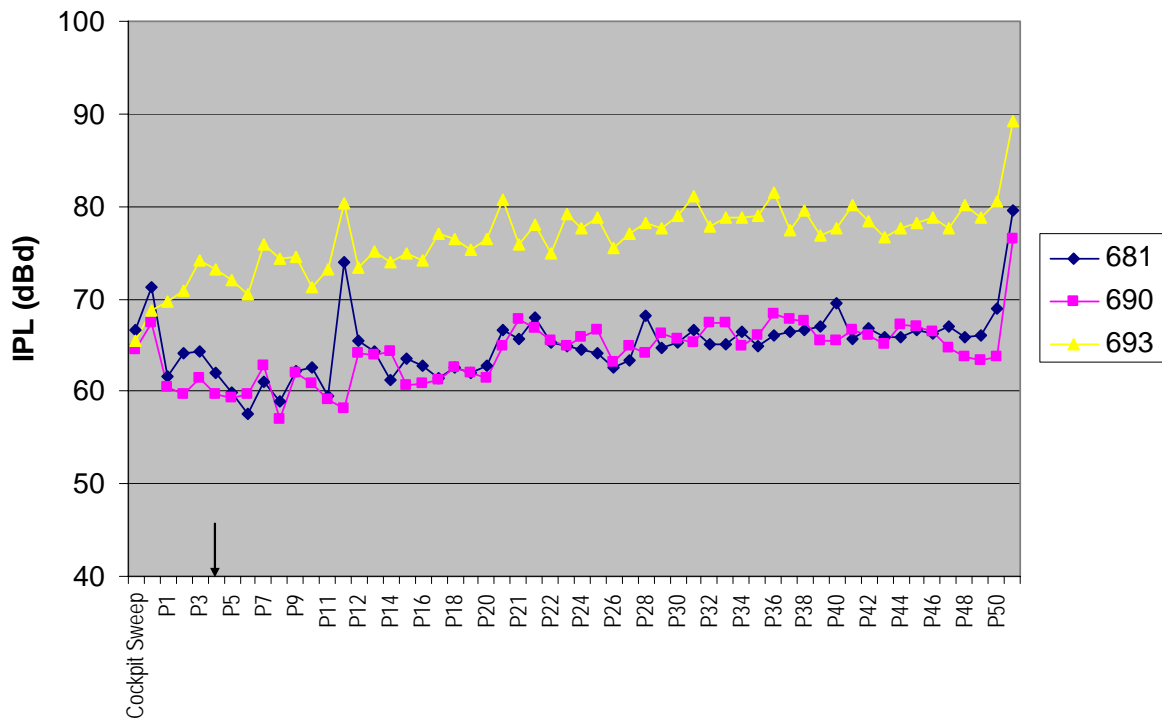




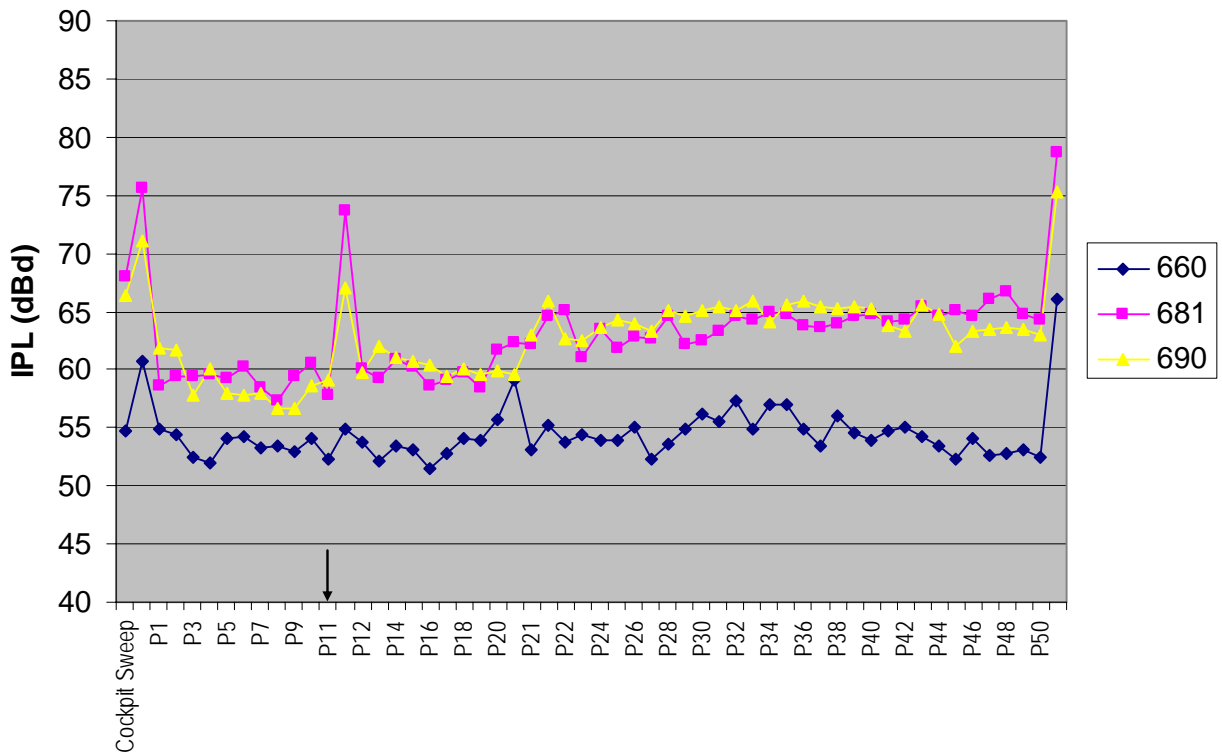
**Figure 7 – Glideslope**



**Figure 8 - ATC Upper**



**Figure 9 - ATC Lower**



**Figure 10 - DME Left**

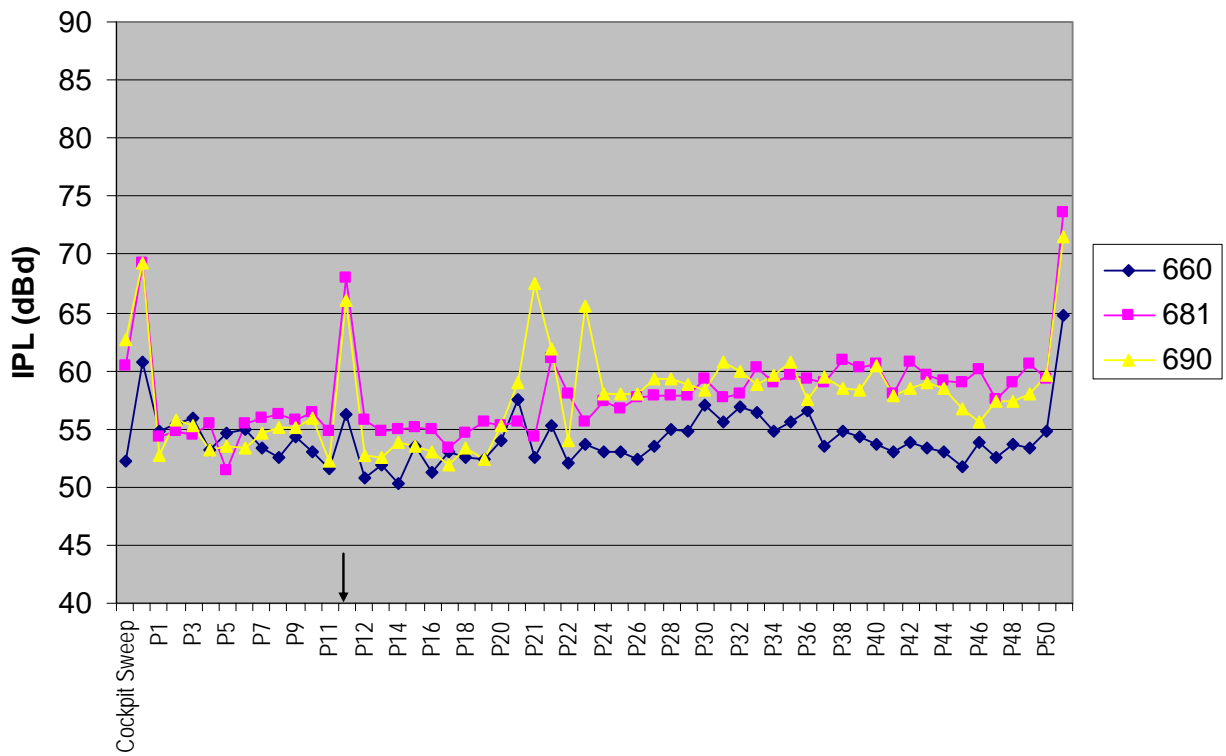


Figure 11 - DME – Right

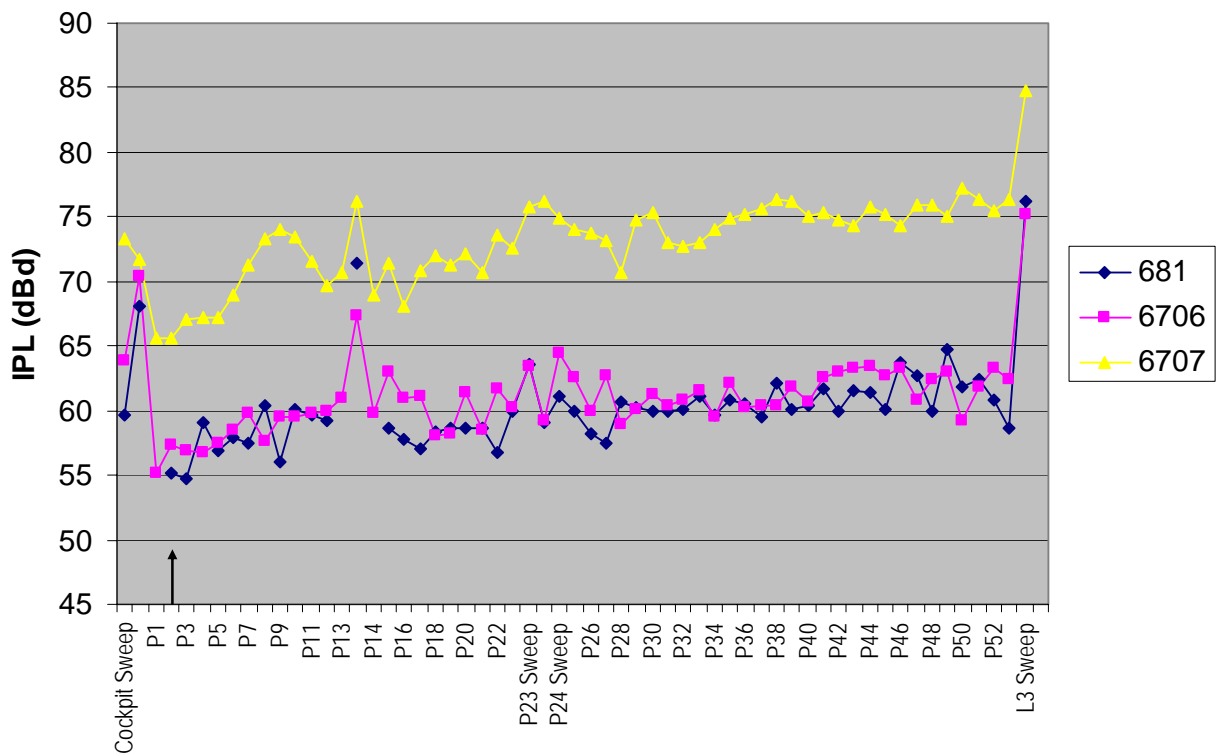
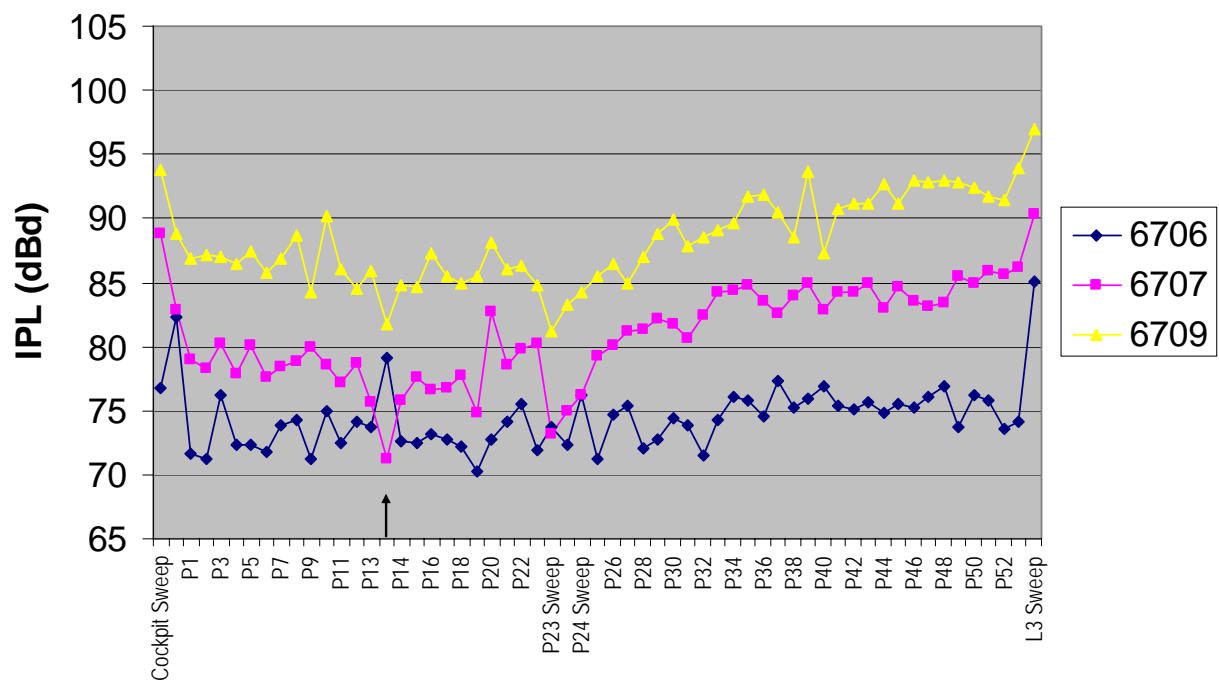


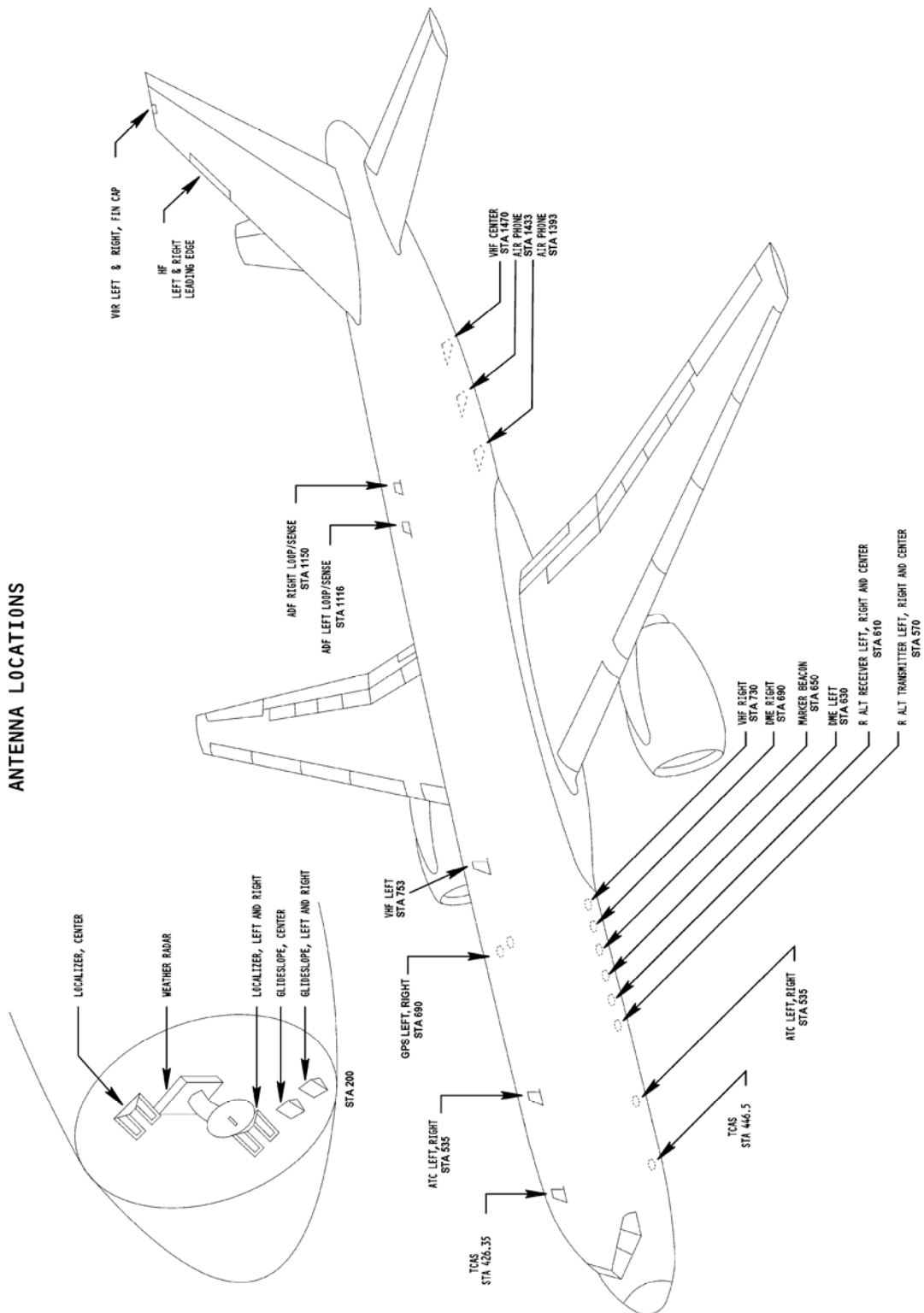
Figure 12 - TCAS Upper



**Figure 13 - GPS**

# BOEING 757

## ANTENNA LOCATIONS





## ATTACHMENT 3



**Figure 1 - 677**



**Figure 2 – 681 (Left Side)**





**Figure 3 – 681 (Right Side)**



**Figure 4 - 6709**





**Figure 5 – 690 (Inside Hangar - First Class Windows)**



**Figure 6 – 690 (Coach Windows)**



**Figure 7 – 690 IPL Measurement Using Bicon Antenna**



**Figure 8 - Song Interior**





**Figure 9 – Song Test Equipment Location Near R2 Door**

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14. ABSTRACT  Path Loss Measurements were obtained on three (3) GPS equipped 757 aircraft. Systems measured were Marker Beacon, LOC, VOR, VHF (3), Glide Slope, ATC (2), DME (2), TCAS, and GPS. This data will provide the basis for assessing the EMI (Electromagnetic Interference) safety margins of comm/nav (communication and navigation) systems to portable electronic device emissions. These Portable Electronic Devices (PEDs) include all devices operated in or around the aircraft by crews, passengers, servicing personnel, as well as the general public in the airport terminals. EMI assessment capability is an important step in determining if one system-wide PED EMI policy is appropriate. This data may also be used comparatively with theoretical analysis and computer modeling data sponsored by NASA Langley Research Center and others.						
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